THE QUARTERLY

JOURNAL OF SCIENCE.

OCTOBER, 1872.

I. THE ORIGIN OF THE GREAT CYCLONES.

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IN his sketch of the early triumphs of science in England, Macaulay tells us, "One after another, phantoms which had haunted the world through ages of darkness fled before the light." It was no wonder that men, taught by Bacon to investigate instead of to imagine, should have learned more in a day than all their fathers for a thousand years before them. It was not strange that unscientific prelates and courtiers and literary gentlemen should have made brilliant discoveries in chemistry and physics, where, for centuries, professional alchemists and schoolmen had floundered in their own muddled dreams. But it seems passing strange that the phenomenon of storms and tempests should have escaped the eye of true science till quite recently, and remained so long one of those "phantoms" of which the historian spoke. The time has certainly arrived for a vigorous invasion of the vast and splendid, but yet unsubdued, domain of meteorology. The key to success in this aggressive movement, I conceive, lies in the determination of the cause of cyclones and the generation of the storms which perpetually travel over their ordained and fire-sprinkled paths. As Professor Buys Ballot, the eminent chief of the Royal Dutch Meteorological Institute, in announcing the scheme of inquiry for the General Congress of Meteorologists to be held this year, has so well expressed it, "*the origin of depression systems is the great problem to be solved.*" This solution I have attempted here. I am not unconscious of its importance and difficulty. But no scientific inquiry conducted, as I shall strictly conduct this, upon the exclusive principle of a sufficient induction of observed facts, can be justly regarded as presumptuous. It is the glory of such a method of inquiry that while it risks nothing it has the best opportunities for solid and splendid acquisitions, and may not inaptly be compared, as some one has suggested, to

Wellington's strategy in forming the famous lines of Torres Vedras.

The only theory for the generation of cyclonic storms which has engaged more than an ephemeral existence is that of M. Dové, the distinguished meteorologist of Germany. Taking the West Indian cyclone as the type of all others, beginning in the intra-tropical regions and extending into high latitudes, M. Dové is the well-known advocate of the doctrine that these storms "Owe their origin to the intrusion of the upper counter trade-wind into the lower trade-wind current."* Without now entering into a discussion of this hypothesis, it will be proper for me to mention a different one advanced some time ago by myself, as a substitute for the older one of Dové, and as affording a satisfactory solution of all tropical storms and cyclones. This hypothesis, which will here be fully stated, was also based on the agency of the trade-winds, but in a manner totally distinct from that assumed by the German meteorologist; and in the original statement of my own views it is asserted that "the origin of cyclones is found in the tendency of the South-East trade-winds to invade the territory of the North-East trades, by sweeping over the Equator into our hemisphere, the lateral conflict of currents giving an initial impulse to bodies of air, by which they begin to rotate." This explanation will take us aside for a while to notice the law of storms and the region of the trade-winds, upon which, according to the two hypotheses, the tropical storm has its birth.

It can hardly be necessary in stating the law of storms, as first announced and established by Mr. Redfield, to do more than call attention to its fundamental condition. In Europe, meteorology has made rapid strides. Since the institution of the Weather Bureau in the United States, the eye of every American has become familiar with the daily isobaric and other isometeoric lines on the weather maps of the War Department, displaying with the fidelity of an automatic instrument a tri-daily photograph of the never quiet aërial ocean. He has learned to watch its mighty pulsations. He traces from day to day the exactly delineated area of every passing storm, and follows its cloud-led march from shore to shore of the Continent. Nothing of importance in the meteoric world in his own country can escape him, for he is in telegraphic communication with every part and corner of its vast territory.

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* Dove's Law of Storms, p. 264.

While philosophers and meteorologists, in many countries less favoured with a system of weather telegrams, have been discussing and disputing the reality of the law of storms, he sees it daily verified and is himself a storm warner.

That "law," first elaborated by Mr. Redfield and Col. Reid, simply stated, is this:—"All gales or hurricanes are great whirlwinds, in which the winds blow in circuits around an axis vertical or inclined; that the winds do not blow in horizontal circles, but in sinuous spirals towards the axis, a descending spiral movement externally, and an ascending one internally, at the cyclonal centre; that the direction of apparent revolution is always uniform, being against the motion of the sun or against the hands of a watch turned face upwards, or from right to left in the northern hemisphere, and just the contrary in the southern hemisphere. The moment a barometric fall occurs, or, in any way, a sinking or depression of the atmospheric sea takes place, that moment, from all sides, the air begins to press inwards in radial lines upon the vortex. If the earth was not revolving on its axis, and the surface was smooth and polished so as to offer no friction, the air currents would flow in the direction of the spokes of a well-made wheel; on reaching the centre they would ascend as in a hollow and somewhat erect cylinder of air until they had restored the equilibrium of the agitated mass. The earth's diurnal motion diverts them, however, to the right. Still they go forward to the centre of agitation, and, on reaching it, ascend. In ascending they grow cooler and cooler; their interstices grow smaller and smaller; their moisture is wrung from them at the altitude of a few thousand feet; and the evolution of the latent heat stored away in the vesicles of their aqueous vapour now begins, and the tempest begins to rage in earnest. This process goes on as long as the storm cylinder or centre is fed with the vapour of water, and, as we shall presently see, it ceases when that supply fails, as quickly and necessarily as the wheel or screw of the steamship ceases to revolve when her engineer cuts off the steam from her cylinders.

Thus we behold the cyclonic meteor set in motion internally from the circumference to the centre, simply by the formation of an atmospheric depression, and we see that internal motion—the air blowing in sinuous spirals upon the centre—prolonged, sustained, or intensified by the liberation of the latent caloric of aqueous vapour condensed into rain from the ascending air-current.

From this philosophy of the cyclone—which, as far as it relates to the agency of aqueous vapour, is entirely inductive—it would be inferred that great cyclones, hurricanes, and typhoons ought to occur in regions of great evaporation, where the intro-moving winds would take up large quantities of moisture for the central area of the storm, and keep its furnace well supplied with appropriate fuel. I need hardly say that such an influence is sustained by actual observation all over the globe. The tropical hurricanes of the West Indies are violent indeed. But they do not attain the violence of the East Indian typhoons; in the former the barometer does not fall so low, and for a very obvious reason. The water of the equatorial current in the Atlantic, which leaves the Antilles, has been but a short time beneath the tropical sun in its passage from the coast of Africa. The waters of the Bay of Bengal, the China Seas, the South Indian Ocean, have been more than three hundred days under a vertical sun, and are all aglow with its heat, and the evaporation from their superheated billows exceeds that of all other waters on the globe. The moment a storm centre is formed in the Indian Ocean, and the intro-moving air currents reach it, the quicksilver suddenly drops in the barometric tube, and before the mariner can reef his sails, they are often torn into a thousand ribbons, and his vessel thrown on her beam ends.

It is a remarkable fact that the hurricane season in the West Indies closes with *heavy rains* in the early or middle part of November, when the sun has been nearly two months below the line, when solar evaporation in the Caribbean Sea has been partially arrested, and the reservoirs of the air exhausted of their vapour or storm-fuel by the drenching rains of which we speak.

From what has been said of the immense amount of condensation due to an ascensional movement of air in the storm centre, it must not be supposed that the chilling arises solely from the elevation of the air to colder regions of the atmosphere. As the air ascends into the upper regions the pressure of superincumbent atmosphere is taken off from it on all sides, and it expands and loses heat, the force required for the expansion being withdrawn from the store of heat. The glass receiver of an air-pump full of humid air, when exhausted partially, shows a frost of vapour and clouds within, proving that the process of rarefaction has chilled the contents of the receiver. Air was compressed by Professor Tyndall, by means of a column of water 260 feet high, to an eighth of its original volume, and then allowed to escape by a stop-cock. As it rushed out it expanded so violently and caused such an intense cold that the moisture in the room was congealed "in a shower of snow, while the pipe from which the air issued became bearded with icicles."

We are now prepared to understand the assumed agency of the trade-winds in the production of cyclones.

The South-East trade-wind is in many respects like its Northern counterpart, but decidedly fresher and stronger. In the vicinity of the famous island of St. Helena, and from that rock to the island of Ascension, it is perhaps the most constant wind on the globe. Here its direction is very nearly fixed due S.E., and from the last-named latitude it blows steadily and strongly right up to the Equator, and crosses the line in the winter of the Southern hemisphere with a marked velocity.

The South-East trades occupy a much larger area of the earth's surface, and sweep a wider zone than do the North-East trades. The celebrated navigator, La Perouse, writing in the month of September, 1785, while on his way to the South Atlantic, says:—"We crossed the Equator on the 29th of September in 15½° west longitude. Those sailors are quite in error who are afraid of finding calms near the line at this season;" and the reason for this observation is that the belt usually known as the equatorial calm belt is actually and constantly penetrated in July, August, and September by the South-East trades, which have come up from below the Equator. Coleridge, availing himself of the popular notions of his day, delineated this region of calms as a terrible one for the mariner, in which his bark was calm-bound under a hot and copper sky—

> "Day after day, day after day,
> We stuck; nor breath, nor motion;
> As idle as a painted ship
> Upon a painted ocean."

But, unless we except certain seasons of the year, this once-dreaded region is not more tranquil than certain other spots and districts of the Atlantic to which the name of Horse Latitudes has in our time been given, but which was called by the old Spanish sailors *El golfo de las yeguas*, "the mare's sea," to denote its roughness. Certain it is the South-East trade does cross the Equator in summer, and make itself felt, at least as far as the parallel of 10° N. Mr. J. K. Laughton tells us "The S.E. trade in the hurricane months blows across the line far to the northward." Dampier, Horsburgh, Dové, Capt. M. F. Maury, and I believe all writers without an exception, have fixed 10° or 12° N. as the limit reached by the S.E. trade in summer—a fact which is in remarkable contrast with the winter southern limit of the N.E. trade, which, as we have seen, does not attain a lower latitude than 3° N., or, as many observations give, 5° N.

Besides this fact, we have in the S.E. trade a powerful and not a gentle wind. If we compare the average velocity of the South-East trades with that of the North-East, we shall find, according to the researches of the U.S. National Observatory, that "velocity of the North-East trades is from 14 to 18 miles per hour, that of the South-East from 25 to 30 miles an hour." Add to this the yet more significant fact, from the same authority, that "The force of the trade-winds (S.E.) as determined by the average speed of 2235 vessels sailing through them, is greater between 5° and 10° south than it is between 25° and 30° south," and we have what amounts well nigh to a demonstration, that the South-East trades do violently overleap the Equator. Experiments also show that while the average force of the freshest trade-wind in the North Atlantic taken just abaft the beam of vessels is sufficient to propel them 6 knots an hour, that of the S.E. trade-wind is sufficient to propel them 8 knots an hour.*

With the facts now before us, we are in a position to weigh and measure the wind-forces which meet and conflict in the torrid zone, and, as it is claimed, give the initial impulse to so many hurricanes or cyclones annually; and especially to those which are generated in the West Indies, and which subsequently come home to every American citizen whose habitation lies east of the Rocky Mountains, from the Gulf of Mexico to Lake Superior and Maine, and, I may also add, to every European.

It is a marked trait in nature's workings, that the most feeble and insignificant force may, and often does, work gigantic results.

Scientific travellers tell us that, in their ascents of the Alps, far up amid its sublime and dreadful acclivities, the cautious guide is often so situated that he dares not open his lips to speak lest the faintest agitation of the air may dislodge immense masses of ice, and bury the party in an instant beneath the avalanche or storms of snow. It can be demonstrated by the laws of mechanics that the upward discharge of a single cannon will produce a cylindrical vacuum in the upright path of the projectile, and that, under a calm and still atmosphere, such a discharge will generate a cyclone. The spark from a rushing locomotive may fire a prairie or a vast sea of forest, as has recently been instanced in the majestic and expansive conflagrations of the North-West; and, we must remember, that a sound generalisation does not demand of the physicist that he should assign a cause commensurate with every effect he sees; but only such a cause as is equal to the origination of such an effect, or one that is sufficient to initiate it. The engineer of the *Great Eastern* moves with perfect ease the small lever which opens his steam valve, and, instantly, the mammoth steam-ship responds; her wheels begin at first slowly to revolve, condensation in her engines commences, and soon the vessel is pushing back the mighty waters and cleaving her way through the ocean. The touch of the engineer's hand has only opened a way for the pent-up energy of her boilers to come into play; all the manual force exerted in occasioning this result, if directly applied to propelling the ship, would not have moved her an inch. To revert to the former illustration, it has not done as much to overcome the inertia of the floating leviathan as is exerted by the tender foot-fall of the chamois on the glacier of Mont Blanc, which sends the ice mass, whirling and leaping with terrific ruin, thousands of feet below. It must now be evident to the reader that there is a remarkable coincidence between the occurrence of West Indian hurricanes and the conflict of the two great trade-winds.

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* MAURY's Sailing Directions, p. 853.

(1). This coincidence is true in regard to PLACE. The West Indian cyclones are generated just where the hypothesis I have advanced would lead us to look for them. "The West Indian hurricanes arise," says Dové, "at the inner edge of the zone of trade-winds N.E. in the so-called region of calms, where the air ascends and flows away in the upper strata in the direction opposite to that of the trade-wind. This renders it probable that the primary cause of the cyclone is the intrusion of a portion of this upper current into that which lies underneath it.* The latter part of this sentence is conjectural, but the former the geographical fact with which we have to do. Loomis says, "The West Indian hurricanes generally originate near the equatorial limit of the trade-winds, where these winds are irregular between the latitude 10° and 20° N., and longitude 50° and 60° W. This is just the region of trade-wind interference, just the territory on which the over-leaping S.E. trade, deflected a little by the land-mass of

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* Dove's Law of Storms, p. 135.

South America, comes in conflict with the lighter and feebler N.E. trade. I may further point out the equally striking coincidence, due to analogous causes, that it is in the very same region, the northern equatorial current of the North Atlantic and the southern equatorial respectively, under the propelling influence of the N.E. and S.E. trade-winds, rush together off the archipelago of the windward Antilles, and penetrating the meshes of this insular network move westward to form the Gulf Stream.

(2). But striking and suggestive as are the coincidences between the origin of cyclones, and the conflict of S.E. and N.E. trade with regard to place, they are equally or more striking with regard to the TIME at which cyclones occur.

The West Indians occur most frequently from July to October. From Poey's "Chronological Table of 365 West Indian and North Atlantic Hurricanes, from 1493 to 1855," it appears that 42 occurred in July, 96 in August, 80 in September, 69 in October. The most violent hurricanes occur between the 15th of August and the 15th of October; but that of August 10, 1831, and that of October 29, 1867, may be mentioned, with others, as noted exceptions to the remark. But, as Professor Eastman well states, "Storms of this class seldom, if ever, occur in the West Indies later than the 20th or 25th October; in fact so well defined is this limit supposed to be by the residents in that portion of the world, that the end of the "hurricane season is believed to be more nicely determined* than even the change of seasons."

(3). In point of *intensity* also the coincidence appears to be marked, not merely at the time when the irruption of the S.E. trade is most impetuous, but in August and October —the extremes of the "hurricane season"—which are the two months of the most violent cyclones, as we may easily see, the beginning and close of the battle of the trades are the periods of most desperate conflict in the West Indies. This conflict, it must be understood, is never settled, but the contest is fought on another line, or rather upon a line which ever sways backward and forward, at right angles to the meridian, and nearly under the vertical sun.

(4.) The theory by which I have sought to explain the generation of cyclones is fully sustained by the laws of mechanics, as Professor Eastman, speaking of Dové's theory, and has Dové himself has shown, "a mass of air moving towards the N.N.W. will, on coming in contact with the trade-wind moving towards the S.W., have a general direction towards the W. by N. (the regular path of the West India hurricane), and will at the same time fulfil all the conditions necessary to generate a cyclonical motion in the direction E., N., W., and S.," *i.e.*, against the hands of a watch. According to the old Redfield Law of Storms, Mr. Buchan, discussing the moving dust whirlwinds and pillars of sand so frequent in the East, says, "The direction of the eddy of the whirlwind, especially when of small diameter, differs from the rotation of the winds in a storm, in that it may take place either way according to the direction of the stronger of the two winds which gave rise to it. Thus, suppose a whirlwind produced by the brushing of a north against a south wind, then if the north wind be the stronger, and on the west, the whirl will be in the direction of the hands of a watch; but, if the south wind be the stronger, the eddy will turn in the opposite direction* (cyclonical). In the theory, the south wind (the S.E. trade), as we have seen, is the stronger. Dové himself, though advocating a different view, admits the mechanical correctness of this; and, indeed, were this the place, it were easy to demonstrate its truth by a direct appeal to mechanical law.

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* See an able discussion of this hurricane by Professor EASTMAN, of the U.S. Naval Observatory; prepared by order of Admiral B. F. Sands.

(5). The TYPHOONS of the East Indies and of the Southern Indian Ocean are explained by the theory now advanced, as happily as are the hurricanes of the West Indies.

According to the testimony of all writers, which may be stated in the words of Professor A. Keith Johnston, "Cyclones originate in the space between the Equator and the tropics near the equatorial limit of the trade-wind during winter, when these winds are irregular, and *during the changes of the monsoons*."† Out of all the hurricanes and typhoons remembered and chronicled since the year 1600, only three or four have occurred near the winter or summer solstice.

It is, of course, impossible here to discuss the exact limits of the monsoons in the East Indies. It is only necessary to examine any monsoon-chart to see that the region of vernal and autumnal monsoon changes and the typhoon regions perfectly coincide. When the South-West monsoon begins in the spring to blow over India it speedily draws upon the belt of N.E. trade-winds in the North

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* Handy Book of Meteorology, pp. 305, 306.

† Physical Atlas, p. 62.

Indian Ocean. Sailors have long known this influence, and called it "the backing of the monsoon." This backing continually enfeebles the N.E. trade, finally absorbs and turns it right about to the opposite point of the compass from which it was blowing. Observation shows that the S.W. monsoon then works its way backwards through the northern trade-wind belt to its extreme equatorial limit. When this process is complete, the S.E. trade, on reaching the Equator, finds no adversary to resist its progress, and sweeps on in the general draught of the S.W. monsoon to swell its force. From May to August all goes smoothly enough. The monsoon has everything its own way, and the seaports of India have their harbours flooded with the sea, and the mountains of India are drenched with torrential rainfalls. In August the monsoon begins to change, and then begins the same conflict, but on a somewhat more terrific scale than we have witnessed in the Atlantic off the Windward Islands in the same month between the aspiring and impetuous S.E. trade and its northern congener.

In my first paper on this subject, published more than a year ago, I said, "In the Bay of Bengal the typhoon would follow in August, from the conflict of the two lateral currents of the South-East trade, and the North-East trade enfeebled by the counter monsoon influence. It is doubtless this enfeebling of the North-East trade that renders it an easier prey to the impact of the South-East trade; and this explains the violence of typhoons, which is greater than that of West India hurricanes."

Within a few weeks my attention has been called to the following brief letter in "Nature" from the distinguished geographer, Mr. Joseph John Murphy, F.G.S., which, as an able argument in point, is here partially quoted:—

"*Origin of Cyclones*—In "Nature" of the 23rd June, 1871, there is an account of a paper, by Mr. Meldrum, on the origin of storms in the Bay of Bengal, showing reason to believe that the cyclones of the Bay of Bengal and the Southern Indian Ocean originate in the meeting of the trade-winds of the northern and southern hemispheres at some distance north or south of the Equator. I do not know of any equally complete evidence on the subject for the cyclones of other parts of the world, but there is very strong reason for thinking that they always so originate. The two trade-winds meet in the Atlantic a little to the north of the Equator; for this reason cyclones are frequent in the West Indies, but unknown over the South

Atlantic, and they are most numerous at the end of summer.—JOSEPH JOHN MURPHY, Old Forge, Dunmurry, Co. Antrim."

On referring to Mr. Meldrum's paper, which I had never before seen or heard of, I discovered with great pleasure that his long-continued and accurate researches beautifully sustain the theory.* Mr. Meldrum gave at length full accounts of the particular storms which verified his belief, but which our space does not permit us to quote.

The writer commenced by observing that in various papers published during the last ten years he had stated as the result of an examination of a large body of observations, that the tropical cyclones of the Indian Ocean south of the Equator originated between two contrary streams of air, viz., the N.W. monsoon and the S.E. trade-wind; and, in a paper read on the 10th of November last, he remarked that what had been found to hold good in that part of the ocean might be found to do so generally.

As, then, observation had shown that the tropical cyclones of the Indian Ocean, south of the Equator, were formed in the belt of the calms between the N.W. monsoon, a continuation of the N.E. trade and the S.E. trade-wind, and nowhere else, there was at least a presumption that the cyclones of the Bay of Bengal were also formed in that belt, at those seasons when it stretched across the Bay, and separated the N.E. trade-wind from the S.W. monsoon; and this presumption was strengthened by the fact that most, if not all, of the cyclones that occurred there did so at the change of the monsoons; that is, when two contrary winds prevailed in the Bay, and were more or less in conflict. These general considerations rendered it possible, if not probable, that the cyclones of the Bay of Bengal were formed between two contrary and pre-existing winds. But that was not sufficient. It was necessary to bring the matter to the test of facts; and this could only be done by examining the observations taken in particular storms.

The storms and cyclones reported and traced by the U.S. Signal Service, as published from day to day in the press telegrams, also seem to establish the theory which was at first put forth with great diffidence. These reports show, in general, that the cyclones which come to us from the tropics and Gulf of Mexico move from the tropics westward, curve to the north and east, and travel upon a parabolic curve, which oscillates with the sun in declination. This curve in summer strikes into the Florida coast, and the storm which moves along its path strikes on the Georgia and Carolina coasts, as did those of the 18th and 26th of last August. Their cyclonic intensity is of course reduced or nullified when they spread themselves on the land, as was noticed in the latter of the two storms just mentioned.

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* Mr. MELDRUM on the Origin of Storms in the Bay of Bengal.

In summer this curve does not run further westward than Alabama and the Alleghanies, and hence the dry and arid season in the north-west, whose plains and prairies are then so parched that the cattle have often to be driven hundreds of miles to the water-course, and kept there till late in October. Dové himself admits that the origin of cyclones is explained "if we assume that a portion of the south-east trade-wind travels far over the Equator into the northern hemisphere."* This I have assumed and proved. My reasons for declining his explanation—viz., that "the primary cause of the cyclones is the intrusion of the upper current (from the coast of Africa) into the (N.E.) trade-wind which lies underneath it"—are quickly stated.

This view is based upon the existence of an abnormal upper current of air which has "ascended over Africa, and flows away laterally in the higher strata of the atmosphere as an easterly wind," and has, to use Dové's words, "some connection with the fall of dust in the North Atlantic,—an occurrence which is frequently observed."—(P. 186).

To sustain this he cites the fact, noticed by Piazzi Smyth on the Peak of Teneriffe, 10,700 feet above the sea, that this dust obscured the sun; and he also cites the remarkable occurrence of the erupted ashes of the volcano of Coseguina, in Central America, being "carried by the upper counter trade-wind, not only as far as Kingston, in Jamaica, a distance of 800 English miles against the direct (or surface) trade-wind, but also 700 miles to the westward, where they fell on the ship 'Conway,' in the Pacific Ocean." From this well-known fact he infers that "In the higher regions of the atmosphere the air does not always move regularly from S.W. to N.E., but that the regularity of this movement is interrupted by currents flowing from E. to W." (See "Law of Storms," p. 186).

It must be allowed that these are very slender and meagre inductions of fact to bear the weight of his hypothesis. I do not deny that his upper current colliding with the surface trade would be able to generate a cyclone ; but the existence of such an upper current in the cyclone region is not established by safe *observations*. The Peak of Teneriffe is near the African coast, and under the influence of the North-African monsoon. It is near the parallel of 28° N. lat. and 15° W. long., while the West-Indian hurricane region is in 10° to 15° N. lat. and 60° W. long. The sea-dust observed off the coast of Africa, when examined by the great German microscopist, Ehrenberg, was distinctly pronounced by him full of "*South-American Infusoria* ;"* the same was true of all the blood-rains and sea-dust of the Cape Verde Islands, Lyons, Genoa, and other places, showing a southerly or S.W. current in the high atmosphere, not from Africa, but from South America, and, as Prof. Eastman says in his little publication (p. 15, 5th clause), "If a mass of air from the return trade-wind, moving from the S.W., be precipitated into the N.E. trade-wind, it will meet with equal opposition along its whole front, and *there will be no tendency to a rotatory or cyclonical motion*."

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* Law of Storms, p. 264.

On the 18th of July, when Prof. Dové's easterly current from over Africa should have been blowing, the astronomer on the Peak writes :—"Long we gazed at the novel upper clouds sailing over our heads from the south-west" (!) "and having moved his station to Alta Vista, 10,700 feet high, on the 25th of August," he went down to Orotar on business, and "leaving the station with a south-west breeze, changed it, at an altitude of 6,700 feet, to a north-east. Returning again on the 30th, he experienced a similar change at about the same height, the strength of the wind increasing as he ascended. Arrived at the station, the south-west wind was found to be blowing with great violence, and it so continued to blow for more than a fortnight, when, as the winter seemed to have set in, the party quitted the mountain."†

Here we see, by the very testimony Prof. Dové depends upon, in the very midst of the "hurricane season" in the tropics, when his fancied easterly wind should have been in full blast, Piazzi Smyth found only a south-west wind. There is *no evidence of an easterly wind* except the long-disputed dust of Ehrenberg.

If the stratum of the regular N.E. trade-wind is, in Central America (what Piazzi Smyth, as we have just seen, found it to be at Teneriffe), 6,700 feet deep (and it is probably three or four times as deep), it is easy enough to see how the ashes which fell on the ship "Conway" while in the Pacific, S.W. of Coseguina, were borne thither to her deck, in the superior part of the surface trade-wind; and such is the generally-accepted interpretation of the incident among geographers.

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* See EHRENBERG'S Passat Stanb und Blut Regen.

† See PIAZZI SMYTH'S Teneriffe, p. 113.

Lastly, if the ingenious theory of Prof. Dové explains the phenomena in the West Indies, it is totally inapplicable in the East Indies. The inference forced upon the mind by what has been proven of the mechanical and lateral interference of the great bodies of trade-winds, from both hemispheres, fully explains the *origin* of the rotatory motion, and the further development of the cyclone will follow from what has been already laid down. If the rotation, at the *moment* of interference, be anticyclonic, *i. e.*, with the hands of a watch, the intro-moving winds will, before they reach the depressed centre of the nascent cyclone, feel and obey the mechanical or diurnal motion of the earth, and they will quickly control the rotation of the atmosphere, and force it to become cyclonic. Once formed, however small, and though no larger than "*a man's hand*," the meteor grows, and, being embedded in large air-currents, begins its progressive movement. It has often seemed unaccountable to me that Mr. Redfield did not see and use this solution of cyclones. He appears to have at one time entertained it, but dismissed it, because, to use his own words, "it cannot always explain the uniformity of the direction of rotation, nor the continued activity of the storms in their progress to other regions and in higher latitudes, where their greatest violence is sometimes developed." But, as we have demonstrated, "the uniform direction of rotation" is fully explained by the earth's rotation, and the "continued activity of the storms" by the continued or increased supply of aqueous vapour to their centrical cylinders and the ensuing condensation, acting and reacting upon each other. It is not a fact that the storm continues its activity from the momentum of the first rotation, as the fly-wheel of a machine set revolving by a single impulse, but the rotatory intensity rises or falls with the rise and fall of the barometer in the centre of the meteor.

It is all-important, in the practical application of this whole subject, to bear in mind the movement of the sun in declination.

The solar forces, marshalled around the Equator at the time of the Equinox, may be viewed as the extended lines of some immense army in position, and girdling the entire globe on this great circle. They must be daily conceived of as in motion—now, with slow, but steady and unfaltering tread, marching upon meridian lines to the northern tropic; and now, having faced about at our summer solstice, with unchanging step countermarching toward the southern tropic. The day's march of this imaginary but real host, if measured in a line running due north and south, is the invariable distance of about 15 geographical miles. Before its forward and gleaming movement, either north or south of the Equator, and in front of its ever-outstretched lines, all opposing climatic forces waver, and finally give way. The tropical belts of calms, the zones of the perennial trade-winds, the bands of the fierce anti-trades, the monsoon influences, barometric areas, the cyclone-breeding districts, ocean currents, gulf streams, nay, the very ice barriers that have intrenched themselves in strong cordon within the mysterious periphery of the polar circles, swaying back and forth, up and down on the earth's surface, in ceaseless vibration, ever and everywhere follow the lordly sun in his declination, and strictly adjust their movements to his.

In nothing that has been said has it been at all my design to assert that cyclonic storms originate nowhere but in the intra-tropical regions and under the causal influence of the conflicting trade-winds. I have discussed only the great storms of the parent-zone of aërial disturbance. The celebrated Royal Charter Storm, charted by Admiral Fitzroy, and so memorable in meteorologic annals, is a type of a large number that originate in high latitudes. No practical meteorologist, accustomed to study every day the atmospheric movements, and to chart the undulations of the aërial ocean—

"Varium et mutabile semper"—

can have failed to notice that the nuclei of storms are formed without regard to latitude. The interference of strong air currents of different temperatures, the upward deflection of surface currents by mountain barriers, producing condensation of aqueous vapour, the flames of a burning city, as Chicago, the widespread conflagration of a prairie, will often produce the physical circumstances which give birth to depressions. In the present state of meteorologic science it may be rash to go further. But, whatever theories meteorologists may devise capable of explaining how rotative or retrograde storms *may be* originated, I have not much hesitation in venturing the opinion that future researches will show, as a matter of *fact*, they are formed chiefly, if not exclusively, along the edges of the great atmospheric currents—the surface currents and the upper currents alike—the polar streams which descend into our valleys with their blasting frosts, and the "aërial gulf streams" which move invisibly, but with benign influence, above our heads. The great problem, therefore, in this view for the modern meteorologist is to produce a chart of the upper atmosphere. If the mechanics of the circulation of the air were half so clearly unfolded as those of oceanic circulation, the science of storm-warning would receive an immense impulse. We earnestly, but respectfully, commend the subject to the congress of meteorologists soon to convene.

II. WEATHER PROPHECIES.

THE science of the weather may be said to have sprung up within the last half century, and we must not therefore wonder that, until very recently, meteorological science has rather been concerned with the weather as it has been, than in prophecying what kind of weather may be expected. Indeed, this is almost the case at the present day; for were it not for the telegraph, storm-signals would be of little avail. Much was gained when, from the conclusions drawn from a large number of observations, a storm could be telegraphed from any place as *coming*, instead of as happened. This stage of the science is perhaps as far as can be usually attained in the present day; in some future time, from the careful study of the laws, it may be possible to predict, with average certainty, the state of the weather from day to day, or even for several days to come. It remains to be seen how far this power has been attained; and it may not be uninteresting to notice, in passing, the very unstable ground upon which weather predictions were founded before meteorology included this second division.

Whether we take as type the old dame's faith in the gambols of her cat, the high flight of some birds and the low flight of others, the "camel" in the clouds, the chirruping of grasshoppers, or Marshal Beaugaud's rule—

> "Primus, secundus, tertius, nullus,
> Quartus, aliquis,
> Quintus, sextus, qualis;
> Tota Luna talis"—

we have much the same arbitrary system, or rather want of system, although these signs may not be without some definite cause, more or less remotely connected with coming changes in the weather. In many country places it is common to hear it remarked that "the rain will soon clear up, for the birds are singing;" the coming change is perhaps already sensible to their more delicate organisation. There is also the appearance of the clouds; and to this indication even the lamented Sir John Herschel attached somewhat of a reliance, in that "anvil-shaped clouds" portended a gale of wind. But as a rule, the moon may be considered to hold the first place of influence upon weather predictions. Halos round the moon are the phenomena most commonly observed, and are readily explained by the laws of the reflection of light from the particles of aqueous vapour suspended in the atmosphere. When these halos are coloured, we may infer the presence of watery particles in the higher regions of the atmosphere; when the halos are white, we may conclude that the particles are frozen, and expect cold weather. Crossed halos, mock moons, or highly developed phenomena, indicate larger crystals of ice, and probably frost, hail, snow, or heavy rain after three or four days, according to the season of the year. Similarly the laws of reflection of light indicate that the cause of a deep purple morning or evening sky is the large amount of moisture present in the atmosphere. Another effect of the moon, when at the full, is to clear the sky of cloud, traceable, says Sir John Herschel, to a distinct physical cause, the warmth radiated from its highly heated surface; though why the effect should not continue for several nights after the full remains, in the opinion of the same accurate observer, problematic. Other lunar prognostics, founded on arbitrary rules, as to the time of the day or night at which the changes or quarterings take place, are worse than useless, for they are calculated to mislead, and are generally included in almanacs or note-books intended for sale only, being in some cases attributed to an eminent meteorologist or astronomer—Sir W. Herschel or others.

It is of course far from our purpose to enter here into a disquisition on the theory of the trade and anti-trade winds, and their barometrical indications—subjects that can be usefully discussed only in a treatise on meteorology: we limit ourselves to the present position of weather prognostics, although it must be admitted that any advance yet made or likely to be made in prognosticating the weather arises from the study of such recurrent phenomena, the investigation being much aided by the highly developed character of the laws of the expansion of gases, upon which laws the theory of the wind is founded. Thus we know that a rise in the barometer, together with a fall in temperature, as shown by the thermometer, indicates the approach of a cold northerly current of air; while a fall of the mercury in the barometer, with a rise of that in the thermometer, indicates that a southerly or warm air current is on its way. Northerly currents may include winds from the north-west and north-east, as well as from the north; similarly, southerly currents may include winds from the south, south-east, or south-west. When the barometer rises whilst a north-east wind is blowing, with prevalent hail, rain, or snow, there may be no change. Of barometrical indications alone, it is generally known that a rapid rise portends changeable weather; a slow rise, the contrary; a rapid fall, heavy wind, rain, and snow; while a fluctuating height of the column of mercury indicates unsteady weather. With a heavy gale of wind in the east or south-east, changing south, the barometrical column may fall until the wind shifts its quarter. Upon such observations did Admiral Fitzroy base his code of instructions, now to be found by the side of every barometer, his forecasts depending on the indications of the barometer and thermometer, with observations as to the direction and force of the wind with regard to time and place, and its previous course taken altogether. These indications are thus not absolute, but relative to the preceding state of the weather. But also these indications are valid for only a short interval before the actual advent of the storm; and in some instances, as in the Hyperborean storm of 2nd and 3rd October, 1860, the interval is too short for any advantage to be taken of the notice. The particulars of this storm, which presents in true character the difficulties which the meteorologist must encounter, are too interesting to be omitted, and we shortly recount them from the complete and admirably-conducted investigation published by Professor C. Piazzi Smyth, in the Annals of Scottish Meteorology for 1856 to 1871. The term *Hyperborean* has been employed to prevent confusion with tropical hurricanes; it has also been called, from its essential locality, the Edinburgh storm. We have to consider only the practical lessons to be deduced from the observations of this storm; the account of the actual observations must be read from the before-mentioned report of Professor Piazzi Smyth. First, then, the barometric notice was insufficient and too local to be of service, while the storm was too quick in its movements. St. Hilda is the most westerly station; and even if the storm could have been telegraphed thence, the message would have allowed only two hours for preparation, and would have arrived while the eastern men were sound asleep. If a message could have been sent from Iceland the day previous to the arrival of the storm, many wrecks would have been prevented. So that we see the present system of meteorology necessitates not only diligent but earnest watching of the signals that should be afforded by a network of cables and overland wires, for it is by a series of connected observations, extended over a large area, that the usefulness of this branch of meteorology is alone likely to be advanced.

But, it may be asked, what definitive knowledge can be gained, say not of storms, but of average weather for some future period? Here we must again refer to Professor Piazzi Smyth's report on the rock-thermometers at the Royal Observatory, Edinburgh, and to the Proceedings of our own Royal Society for the 2nd of March, 1870, in which predictions of the weather during the winters of 1871-72 are attempted. The rock-thermometers have by their readings shown some well-marked supra-annual cycles, the relation of which to the sun-spot cycles will be known to our readers. And on this point it may be stated that the Radcliffe astronomer announces in his report for 1871, that the *mean* azimuthal direction of the wind at Oxford, rigorously computed from automatic records during the last eight years, varies year by year through a range of 58° on the whole, between maximum and minimum of visible sun-spots; the tendency of the wind to a westward direction increasing with the number of spots; and with such west wind, it is to be presumed, the amount of rain also. "The most striking and positive feature of the whole series of observations," continues Professor Piazzi Smyth, "is the great heat-wave which occurs every eleven years and a fraction, and nearly coincidently with the beginning of the *increase* of each sun-spot cycle of the same eleven-year duration. The last observed occurrences of such heat-wave, which is very short-lived, and of a totally different shape from the sun-spot curve, were in 1834·8, 1846·4, 1857·8, and 1868·8; whence, allowing for the greater uncertainty of the earlier observation, we may expect the next occurrence of the phenomenon in or about 1880·0. The next largest feature is the extreme cold close on either side of the great heat-wave: this phenomenon is not quite so certain as the heat-wave, partly on account of the excessive depth and duration of the particular cold wave which followed the hot season of 1834·8. That exceedingly cold period, lasting as it did through the several successive years 1836, 1837, and 1838, was, however, apparently a rare consequence of an eleven-year minimum, occurring simultaneously with the minimum of a much longer cycle of some forty or more years, and which has not returned within itself since our observations began. Depending, therefore, chiefly on our later observed eleven-year periods, or from 1846·4 to 1857·8, and from the latter up to 1868·8, we may perhaps be justified in concluding that the minimum temperature of the present cold wave was reached in 1871·1; and the next similar cold wave will occur in 1878·8." Between the dates of these two cold waves there are located, according to all the cycles observed, even including that earlier one otherwise exceptional, three moderate and nearly equidistant heat-waves, with their two intervening and very moderate cold waves, but their characters are quite unimportant. With regard to all the waves, it may be just to state that there has been in observation more uniformity, and will be therefore in prediction more certainty, for their dates than for their intensities.

We have thus very briefly surveyed the position of meteorology, and little remains to be said beyond that the results are highly in favour of the hopes of physicists to render meteorology an exact science.

III. THE AMORPHOLITHIC MONUMENTS OF BRITTANY,

COMPRISING THE CIRCLES, AVENUES, CARNEILLOUX, AND OTHER ASSEMBLAGES OF SHAPELESS STONES.

By S. P. Oliver, Capt. R.A., F.R.G.S.

Part II.

We have hitherto assumed that all the megalithic monuments have been constructed for sepulchral purposes, but an important question has been raised as to whether the dolmen-mounds are in any way associated with the circles, avenues, alignments, and other assemblages of upright stones found in their immediate neighbourhood. Is their origin coeval? and, were the lines constructed by the dolmen-builders, or not? Now, as to their contemporaneity; the Rev. E. L. Barnwell* states that "of all the monuments usually called Celtic, whether of pillar-stones, chambers, circles, avenues, &c., the simple chamber, cromlech or dolmen, with or without its covered gallery, is now generally acknowledged to be the earliest." But to us there seems every reason to suppose that the stone avenues hereafter described belong to a period far anterior to that when the menhirs and dolmens were erected, when we compare their shape and position. These assemblages of stones are conspicuous for their want of uniformity, absence of elegance, and, in fact, general shapelessness—some globular, others rhomboidal, &c.—all sorts of irregular, fantastic, rough, and bizarre forms. The finest appear to have been chosen for their majesty of size and bulk alone, and but little heed taken as to how or in what position they should stand as long as they were in their proper alignment; they are erected any side uppermost, as often as not with their heavier portion in the air, being well nigh balanced on their smaller end; so much so, as would lead one to suppose sometimes that they had been designedly so placed. Although it is possible that they were originally thus placed in equilibrium, still it is more probable that they were left in the readiest position which came to hand. There is no trace of their having been fashioned artificially. At all events they present a striking contrast to the isolated pillar-like menhirs of smooth elegant exterior, placed generally with an especial view to their stability, and exhibiting a practical knowledge of the position of the centre of gravity on the part of those who erected them. Many of the menhirs present the appearance of having been fashioned artificially, as at Locmariaquer, where that magnificent specimen, *Le Grand Menhir*, now lying in four pieces, exhibits the artificial handiwork of man; whilst on the south side of the menhir, *La Boulaie* (*Moustoir-ac*), are two sculptured figures in relief, whilst others exhibit fluting, and other signs of ornamentation belonging to an advanced period of art. Again, we know that the custom of erecting monoliths has descended down to historic times; thus we have records of the erection of memorial pillar-stones (the *Bauta*-stones and *Minne*-stones of Scandinavia, for instance, and the *Gullaunes* of Ireland)—

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* Rev. E. L. Barnwell, Archæologia Cambrensis, 3rd series, vol. x., p. 57.

> Blissful a Son is
> tho' born but lately,
> his father already fallen;
> seldom *Bauta-stones*
> bound the folk-path
> save raised by kin to kindred.
>
> The "Elder Edda," Hávamál, v. 71.
> *Professor Stephens's Trans.*

whilst a modern Danish poet, M. A. G. Ochlenslaeger, writes—

> "Rush to arms with ready tread;
> Raise a *Rune-stone* o'er mine head;
> *Rune-stone* rist as Ettin strong,
> Ringing my fame time's waves along!"

Now, we have no historical accounts of the circles, avenues, and alignments being erected. In like manner, the dolmens are still more remarkable for the admirable smoothness, flatness, and clever adaptation of the huge slabs composing them, whilst they, too, are found in many instances elaborately ornamented.

Under the general head, therefore, of megalithic monuments, which includes all the menhirs, avenues of pulvens, and dolmens, &c., we may not be wrong in applying the distinguishing term *Amorpholithic* to the lines and circles in Brittany, or to any other assemblages of stones of a similar shapeless character.

On this characteristic difference we venture to suppose that the stone avenues are attributable to an age considerably anterior to that of the dolmen-mound builders.

Mr. Fergusson infers, as far as speculation is possible, that the French examples of rude stone monuments are, as a rule, of earlier date than the British or Scandinavian, and he denies that the semicircular or quadrangular enclosures can be classed with stone circles proper, such as those of Wiltshire and Cumberland, Moytura and Stennis, so far as almost to deny the existence of circles in France. We are almost inclined to agree with him.

If the isolated menhirs were erected by the same peoples or their ancestors, it is not likely that they would be placed so as to interfere with the evident design of the alignments; an example of which interference we find at Kermario, where a single intruding menhir rises abruptly amidst the smaller stones of the avenues, of which it is wholly independent, and therefore is probably a subsequent erection.

In spite of their propinquity (for we find many instances of menhirs and dolmens on either side of the lines, likened by some French writers to the outposts of the main army; but which M. de Freminville calls "*pierres d'avertissement,*" which were placed to warn the approaching intruder lest he should profane the neighbouring Druidical sanctuary), it seems not unlikely that there was no connection between the lines and assemblages of amorpholiths and the other megalithic structures, or between the races of men who constructed them: on the other hand, it is not improbable that the most suitable stones of the more ancient lines were often taken to construct the neighbouring cromlechs. In opposition to this we cannot help admitting that there seems to be some analogy between the narrow entrance gallery leading to the chamber, sometimes circular, of the dolmen-mounds, and the narrow avenue, which widens as the circle is neared.

The French *savans* appear to have confined their labours to the contents of the interiors of the dolmens, and, with the exception of a few vague speculations, have altogether neglected to examine thoroughly the gigantic stone circles and avenues, which are amongst the most conspicuous and renowned objects in Brittany. The celebrated stone avenues of Carnac are a series of alignments in the Commune of that name extending from the borders of the Commune of Trinité to a spot between Carnac and Plouharnel. It has been taken for granted that these alignments were continuous; and it is to the careful measurements and plans made by two English gentlemen, Sir H. Dryden and the Rev. W. Lukis, that we are indebted for their discovery that these lines in reality consist of three totally distinct groups.*

These groups are named for convenience after the villages or homesteads nearest to them, viz.—(1) *Menec;* (2) *Kervario*; and (3) *Kerlescant*. It is not improbable that the names of these localities were acquired from the circumstance of the stones standing upon them; for, according to Lepelletier's Celto-Breton dictionary, the word *Menec* signifies a memorial or souvenir, and the word *Kervarv* the place of death. The words *Carnac* and *Carneilloux* are similarly identified with Celtic words signifying a charnel house or ossuary: so in the Cymri we find *Carnedd* as the Welsh for cairn, tumulus, or tomb.

(I). Commencing with the group nearest Carnac, we find a circle of stones, or rather the remains of one, on a slight elevation enclosing several of the farm buildings and dwellings of the village of Menec, after which the group is named. This enclosure is somewhat elliptical in plan, its largest diameter being 92 yards, and its shortest 80.

These stones, which are of uncouth form, are of considerable size and bulk, having an average height and breadth of about 9 feet, whilst they are rather flat and thin. The circle forms the south-western limit of a series of eleven alignments, which stretch from this eminence in a north-easterly direction over undulating ground gradually sloping to a lower level, for a distance of 1025 yards. These lines, the southernmost of which alone meet the circle, are about 11 yards apart at their south-west extremity, and converge to within 5 yards of one another at their further extremity; the size of the stones composing them also diminishing by degrees to an insignificant size. There now occurs an interval of 600 yards before we reach the next group of amorpholiths, the largest of which are on a plateau near the farm of Kervario. Some of these stones are the most gigantic in the Carnac series.

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* The author was unaware of the existence of Mr. Vicars's map, since re-published by Mr. Fergusson, when the above was written.

(II). At Kervario there is no terminal circle, although some scattered blocks of no inconsiderable size may perhaps indicate vestiges of one, but they are more probably blocks left in transit towards their destined situation.

This group consists of only ten lines, 12 yards apart, converging gradually for a distance of about 1250 yards, until the traces of their termination are lost in the plantations of the Chateau de Kercado.

It must be borne in mind that these lines are not absolutely straight, but that each crest of hill or course of brook there is generally observable some slight deviation in direction of the alignments, which has probably arisen from error in the original laying out of the lines, and not from any intentional serpentine plan on the part of the architects, as some writers would have us to believe. These slight deviations go far to prove that the country presented the same features and outlines of contour when these alignments were planned as at present; at all events that its character cannot have materially altered since the days of the construction of the said lines.

(III). The third group to be described, viz., the *Kerlescant* lines, is 400 yards beyond the last-named series, and differs considerably both from the *Kervario* and *Menec* monuments. Here there is a terminating enclosure (somewhat of an horse-shoe form rather than that of an incomplete circle), having a diameter of 96 yards, and associated with thirteen lines of stones extending, however, in the same direction, *i.e.*, to the north-east, but only for a distance of 286 yards, about one-quarter the length of the other groups, and yet the breadth of the whole group is as broad as the Menec series, viz., 110 yards at the western end, giving to each avenue an average breadth of 9 yards, which rapidly diminishes, however, to 5 yards at the north-east extremity.

The eight southernmost lines alone are opposite the horse-shoe enclosure, whilst in a corresponding position opposite the five northern lines is a long barrow, a significant fact. Again, the avenue between the fifth and sixth lines is of a greater width throughout its entire length than the others, the lines composing it being nearly parallel.

There is also a certain symmetry observable, taking the whole thirteen lines together, there being a centre group of three lines, on either sides of which is a broader avenue tolerably parallel, beyond again on either side is a group of five lines converging, the breadths between which are largest on the outermost side. Such are the three groups which, together, constitute the celebrated lines of Carnac, and which have been hitherto erroneously described as one monument. There is another misconception of the site of these circles and avenues, to which I may here allude in order to correct. Some writers speak of "the great plain of peulvens at Carnac* on the solitary peninsula of Quiberon," and "the rugged wastes of Carnac." Now the neighbourhood of Carnac is not the desert that would be inferred from the above-quoted descriptions; there are fields and gardens, farms and villages, woods, and some almost pretty scenery. It is certainly not *on* the peninsula of Quiberon, celebrated for the ill-fated expedition of the Royalists in 1795. The peninsula itself is certainly solitary, and its sand-dunes, by degrees being planted, are not inviting, and there are some remains of lines and circles of stone upon it, which will presently be noticed. Mr. Lukis, in speaking of the view from Mt. S. Michel, talks of vast heaths, undulating country, fir plantations, and small villages, nestling among elm trees, and, further on, of threshing yards and gardens—that is a true description of the landscape, and does not suggest "the rugged wastes of Carnac."

Before considering in detail the characteristics of these curious alignments, we will proceed to describe the other assemblages of amorpholiths in the departments of the Morbihan and Finistère. Our poet laureate, Alfred Tennyson, must surely have had these parts of Brittany in his view, rather than Cornwall, when he wrote in "The Holy Grail"—

> "And then, with small adventure met, Sir Bors
> Rode to the lonest tract of all the realm,
> And found a people there among their crags,
> Our race and blood, a remnant that were left
> Paynim amid their circles, and the stones
> They pitch up straight to heaven: and their wise men
> Were strong in that old magic which can trace
> The wondering of the stars, and scoffed at him
> And the high Quest as at a simple thing."

The most extensive of all the lines is not far from

Erdeven, stretching from the road south of the village towards the south-east for the distance of over a mile and a half. There are, as well as can be made out (for there is sometimes considerable difficulty in tracing these lines), ten lines of stones nearly parallel; the convergence is very slight, the breadth of the lines at the western end being 220, and at the eastern extremity 190 feet. But it must be remembered that these alignments are not actually traceable over the whole extent of this long tract of land; about half way is an eminence, upon which are four dolmens and a long barrow, and here traces of the lines are lost for some distance; but the same number of lines occur again further east, and continue to a spot not far from the huge dolmen of Courconneau, and it is presumed that they formed a portion of the same series. There is a slight deviation between the direction of the eastern and western portions, but only of 3°, the western portion being 117°, and the eastern 120° to the east of the meridian.

From near the head of these lines is an alignment consisting of 25 stones extending in a N.E. direction (42° E. of N.) for a distance of 354 feet. The stones are at present all prostrate, excepting erect menhirs at either end. They are all large stones; in fact the largest masses to be found throughout all the series of alignments in Brittany, the largest measures 21 feet 6 inches long by 10 feet broad and 5 feet thick; two others are nearly as bulky within a few inches. What the meaning of this diagonal line outlying the main body of the Erdeven lines can be is a mere matter of conjecture. It is certain that the blocks lie close together as those composing the circles, at Menec and Kerlescant. If this, therefore, was portion of a circle, it is the sole example of one north of accompanying lines. At the eastern extremity of the Erdeven lines, but at some small distance, is an enclosure of stones nearly oblong, measuring 150 feet long by 85 broad.

Whilst on this subject, it would be wrong to omit any mention of the Red Carnac pebbles—although they are not mentioned in Mr. Lukis's paper, nor even alluded to by the Vannes Society—which occur in multitudes, wherever there are these lines of menhirs. Whether the sites of the alignments have been chosen from the presence of these pebbles, or whether these pebbles are the concomitants or deposed on the sites of the alignments, or whether they form part of a regular geological deposit wholly distinct from any connection with the menhirs, is at present undetermined; and these stones have proved a puzzle to some of the best geologists, and remain as hard nuts to crack for future speculators. I have been permitted to extract the following from the MSS. of Mr. Lukis, sen.:—"Over this district (*i.e.* about Carnac) the surface of the ground produces red pebbles, or worn stones, which at first sight resemble red jasper, but they are evidently belonging to the alluvial of 'the neighbourhood, and have eroded angles and surfaces of a peculiar nature, resembling that of artificial rubbing by the hand of man.' In a note written to me by Dr. John McCulloch, he says, 'I can make nothing of these, unless they are of barbaric art.' These stone pebbles of Carnac and its neighbourhood had also occupied the attention of Dr. Buckland, who likewise considered them as the work of man.

"Mrs. Buckland, his widow, gave me several of them, which had been the subject of much conjecture, and which she said the learned doctor had shown to Chantrey, who endeavoured to persuade him that these might have been used for rude sculpture, in like manner as the bits of white sandstone grit were used by himself when he wished to rub the folds of garments during his employment.

"As these stones are found strewed about the neighbourhood of the menhirs of Carnac, they are given to travellers by the native guides as relics left by devotees at the base of the alignments. These remarkable pebbles differ from those on the neighbouring beach, and are derived from a different source: they are polished usually on all their faces, and have a strong inclination to wear down in a rhomb, rather than, like rolled pebbles on the beach, into round or nodular form. Some appear to flatten on both sides, and become pitted on both surfaces, as stones of silex do when acted on by Eolian force mixed with sand."

The St. Barbe lines are not a very remarkable group; here traces of three lines exist for a distance of three hundred yards. A few of the stones at the head of these lines are of great bulk, the two largest measuring 14 ft. × 12 ft. by 7 ft., and 14 ft. × 11 ft. × 4 ft. 7 in. respectively.

A short distance to the west of these alignments are four stones, which may indicate vestiges of a circle, but they are so doubtful as not to be included in the plan.

Not far from the St. Barbe lines are some conspicuous stones near the mill at Plouharnel; they are called "*Les trois pierres du vieux moulin*;" the largest is prostrate, and measures 16 ft. long × 11 ft. × 5 ft. The two others standing are respectively 12 and 8 feet in height; they seem to have once formed the head of a series of alignments.

At Kerzine, near Plouharnec, are eight lines of stones in a dilapidated state, extending one hundred and fifty yards, whilst in the same neighbourhood, at Kerœnthue, is a line of four large stones, with a detached one at some distance; the larger of these measures 16 ft. × 9 ft. × 5 ft.

The lines at St. Pierre, which lie on the sandy pit of Quiberon, south of Fort Penthievre, are remarkable for the fact that they are detached from the neighbouring circle, which stands ninety-five yards distance to the south-west. Traces of only five lines remain, some of which extend a distance of two hundred yards to the coast line, and possibly before the encroachment of the sea extended still farther.

Such is the description of the most remarkable lines in the Morbihan, and we will now proceed to consider certain noticeable alignments of Crozon, near Brest. The alignments on the promontory of Crozon, near Brest, are altogether on a smaller scale than those at Carnac, and have accordingly attracted much less attention than the latter gigantic remains; but the whole locality is extremely interesting, and literally teems with menhirs, alignments, &c. De Fréminville mentions them, and gives accurate illustrations of the most important lines at Landaoudec and Toulinguet in his volume on the Antiquities of Finistère.

We visited the three most extensive of these alignments, viz. Landaoudec, Leuré, and Logatjar.

The most important of these is on the Lande by the mill of Landaoudec, about half way between Lanvéoc and Crozon villages. The stones are in rather an unintelligible position, and most of them are now prostrate, whilst many of them have evidently been removed into the banks on either side of the road; but still there is the trace of an enclosure associated with orientated lines, which also seem to have converged. Near the eastern extremity of the longest line, which extends some three hundred and fifty yards, are the remains of a kist, and near the mill are some isolated menhirs. The largest stones measure 11 feet 3 inches by 6 feet 6 inches, and 9 feet 9 inches by 4 feet 6 inches. The largest stone standing is 6 feet 9 inches high by 5 feet 6 broad. According to De Fréminville there exist some scattered stones to the north of the mill, but we did not examine them.

The lines of Leuré are about two miles to the westward of the last-mentioned group, and are not far from the little port of Fret, where the steamer from Brest touches. These lines exhibit the features usually distinctive of the Crozon alignments, viz., lines at right angles to one another. The longest line consists of eleven stones, arranged east and west, and extending over one hundred and seventy yards, and a shorter alignment (thirty-three yards in length) at right angles, composed of four upright and three prostrate blocks. In this last line are the largest stones. The upright ones measure 7 feet 6 inches high by 4 feet thick, and 4 feet broad; and 6 feet high by 6 feet 6 inches broad, and 5 feet 6 inches thick.

The menhirs of Gatjar or Logatjar are situated on the down above the village and port of Camaret.

They are by far the most conspicuous and clearly defined of all the alignments on the promontory, as they are not overgrown with furze bushes like the two last-mentioned lines. Here, again, we find the characteristic features of two short lines about fifty yards long at right angles to a longer line two hundred and sixty yards long, lying north-east and south-west. The short lines, one of fourteen, the other of twelve stones, are on the north-west side of the longer line. The conspicuous erect stone is 11 feet 4 inches high; the largest prostrate stone is 13 feet long by 4 broad.

Near all these alignments are outlying menhirs, which M. de Fréminville terms "*les menhirs d'avertissement*," which, according to him, announced to the approaching visitor the vicinity of a sacred enclosure.*

An outlying menhir at Gatjar, close by some stones which may have formed a dolmen, probably stood at the foot of the tumulus which formerly covered the sepulchral chamber. One suggestion made as to the disposition of these alignments at Logatjar is that they commemorate a naval victory, and that the arrangement of the stones indicates the position of the fleets engaged. Admiral Thévenard, true to his profession, is the originator of this idea, in his "Recueil de "Mêmoires relatifs à la Marine," and supposes from the position of these lines, erected on a lofty promontory overlooking the sea, that they represent the order of battle of the Armorican fleets.

There are several other assemblages of stones in this neighbourhood. Amongst others there are some, probably portions of alignments, near the village of Goulien, in the bay of Dinan, and a Carneillou, perhaps a circle, with two parallel alignments stretching eastwards from it, near the cliffs overlooking the Anse de la Pallue, north of the Vec de la Chèvre.

Between the Pte. de St. Hernot and Pte. de Morgatte are also two enclosures, one with an avenue, the other with double lines of stones, bearing the local name of "*Maison du Curé*." On the banks of the River Laber, also, close to the farm Raguénez, is an alignment, and there is a Carneillou at the manor of Trébéron, some distance inland from the coast. This last is curious, from the fact that the tumulus, which appears to be associated with these lines, is named *Le Tombeau d'Artus*.* These last we did not examine, and they are therefore merely mentioned as a record of their existence for the benefit of those who may intend to visit these localities. The accompanying Table (p. 447) gives the principal alignments in Brittany. And the following list shows the angles of orientation, or bearings, of the principal lines of stones; the variation being taken to be 23 deg. W.

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* Antiquités de Finistère, (2nde parte, p. 20 *et seq.*), par M. LE CHEV. DE FREMINVILLE. Brest. 1835.

E. of mag. N.				
57	deg.	0	min.	Camaret.
83	,,	45	,,	Menec tail.
86	,,	30	,,	Kervario.
87	,,	30	,,	Kerdouadec.
91	,,	15	,,	Menec head.
93	,,	15	,,	Kerdouadec.
93	,,	30	,,	Leuré, W. part.
99	,,	0	,,	Leuré, E. part.
106	,,	0	,,	Erdeven head.
113	,,	0	,,	True east.
117	,,	0	,,	Kerlescant.
118	,,	0	,,	Cojou.
122	,,	0	,,	St. Pierre.
135	,,	0	,,	Erdeven tail.
136	,,	0	,,	St. Barbe.
145	,,	0	,,	Kerzine.

It is well worthy of remark that like everything else in Brittany the origin of these avenues, menhirs, &c., is ascribed to the "fairies," a superstition which is common to most if not all countries where anything unusual exists, and where any striking natural or artificial wonder is universally attributed by the local traditions and folk-lore of the native peasantry to pigmies and giants, and later, as priestly

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* *Artus* or *Artur*. "Le roi *Artus* fut enterré dans l'île *d'Aval* ou *d'Avalon*, sur les côtes qui avoisinent Lannion, et à peu de distance de son séjour favori, ce château de Carduel or Kerduel, si célebré par les chroniques de la table ronde, et appartenant aux enfants de M. de la Fruglaye. Les Anglais ont voulu, mais à sort, s'approprier ces localités."—(DE FREMINVILLE.) From this it would appear that the Arthurian legends are as much Armorican as British. *Vide* "Traces of Affinity between the Bretons and the Cornish," "British Quarterly Review," No. 104, October 1, 1870.

Name of department.	No.	Local name.	Description.	Length in yards.	Breadth in feet.		Diameter of circle.	Remarks.
					West.	East.		
MORBIHAN.	1.	MENEC.	Eleven lines of stones with circle at W.	1000	330	195	290	Ends apparently certain.
	2.	KERVARIO.	Ten lines.	1250	323	180	—	E. end undefined.
	3.	KERLESCANT.	Thirteen lines extremely convergent, and Horseshoe enclosure at W.	285	450	205	300	Ends well defined.
	4.	ST. BARBE.	Three lines remaining, original number uncertain.	300	125	—	—	E. end undefined.
	5.	ERDEVEN.	Ten lines nearly parallel, with a diagonal line at N.W.	2680	220	190	—	Ends certain. Gap for some distance about centre of lines.
	6.	ST. PIERRE.	Five lines, the circle distant 290 feet to the S.W. of the head.	210	110	—	180	W. end certain, E. end terminated by sea coast.
FINISTERE.	7.	PLOUHINEC.	Eight lines.	150	240	—	—	Ends uncertain, much scattered.
	8.	CRUCUNY.	— — —	—	—	—	—	Not measured.
	9.	KERDOUADEC.	Two lines, with nondescript enclosure and divisions.	350	—	—	—	Ends not defined.
	10.	LEURE.	One long line and a short one at right angles to it.	172	—	—	—	Ends not defined.
	11.	LOGATJAR.	One long line and two short ones at right angles to it.	267	—	—	—	Ends apparently certain.
ILE ET VILAIN.	12.	COJOU.	Two parallel lines.	140	80	—	—	A great part destroyed.

influence was in the ascendant, to saints and demons. We have classical authority for the popular belief that "there were giants in those days," the Greeks and Romans giving to their god-like heroes supernatural strength. For instance, take the boulder which Turnus in his last despair hurls at Æneas—

"He said no more, but looking round
A mighty stone espied,
A mighty stone, time-worn and grey,
Which haply on the champaign lay,
Set there erewhile the land to bound,
And strifes of law decide:
Scarce twelve strong men of later mould
That weight would on their necks uphold
To-day's degenerate sons:
He caught it up, and at his foe
Discharged it, rising to the throw,
And straining as he runs."

"Nec plura effatus, saxum circumspicit ingens
Saxum antiquum, ingens, campo quod forte jacebat,
Limes agro positus, litem ut discerneret arvis;
Vix illud lecti bis sex cervice subirent
Qualia nunc hominum producit corpora tellus;
Ille manu raptum trepidâ torquebat in hostem,
Altior insurgens et cursu concitus heros."
VIRGIL, "Æneidos," lib. xii., 896 to 902.

In like manner the monkish legends represent the devil throwing stones at some saint, and the saint replying with interest, causing the demon to become lame by some menhir dropped on his toe, &c.

It is not long since the Wiltshire shepherd would scarcely pass near Stonehenge at eventide for fear of surprising the unholy orgies of the giants, and believed in the possibility of becoming the victim of an enchanted pixy-ring. Indeed, the tradition is still prevalent that the stones of Stonehenge were transported by miraculous agency from afar. Geraldus Cambrensis, A.D. 1187, gravely affirms that Stonehenge was removed from a mountain in Ireland to Salisbury Plain by the magician Merlin. In Brittany accordingly we find the neighbourhood of the dolmen-mounds, the peulvans, and avenues to be haunted either by the *dur* or dwarf, and the Karrigwen (Korrigan or Korils), the mischievous elves or the Teuz, the benevolent fairies. Mr. John Lukis mentions that one day he lately visited a fine cromlech on Mr. Bruce Pryce's property, near Cardiff, in Wales; on asking some children who were playing about the name of the spot, they at once replied "*Castle Korrig*," and was particularly struck with the Celtic name of the Breton fairy as applied to a cromlech in Wales. Similarly in Ireland, the mighty *Raths* and *Cathairs* are frequented by "the good people," either in the forms of the lovely and tiny *Sheogues*, the fair and perfect *Lianhaun-shee*, or the quaint cobbler *Leprechawn*. The banshee's wail is heard by the solitary *gullaune* pillar-stone; whilst if we wish to find the mischievous *cluricaune*, we would search the sites of the *carnail* or *carns*, the *murs*, *iiams* or *cumots*, and for warlocks on the *Slieve na Calliagh* or witches' hill. As may well be supposed, archæologists and travellers, both native and foreign, have advanced from time to time innumerable theories more or less ingenious or absurd, and mostly paradoxical as to the origin and destination of the circles and alignments of amorpholiths. Indeed, as many, if not more, strange and opposite conclusions have been drawn by various writers in respect to these monuments in Brittany as has been the case with Stonehenge in our own country.* Innumerable purposes have been proposed for their construction, such as covenants, altars, boundaries, deliverances, sepulchres, and victories, &c., whilst others are in favour of the Epicurean hypothesis of *παρέγκλισις* or arbitrary deflection. The peasantry of the neighbourhood firmly believe that these ranks of stones are the effect of a miracle; the tradition is as follows:—St. Cornely, Pope, and patron saint of Cattle, being pursued by an army of pagan soldiers, and unable to escape, exercised his saintly power, and converted the army into stone; hence these stones are called in Breton *Saint Cornili soudared*. It is evident that this tradition has only originated since the arrival of Christian missionaries in Armorica, where semi-pagan stone worship has yet some hold among the most ignorant folk in the whole of France. The parish church of Carnac is dedicated to Saint Cornely, and a figure of him stands outside the tower, with some rather comical sheep and oxen at his feet. Unfortunately, when this church was built (A.D. 1639), some of the pagan soldiers were broken up in order to supply building material, and there are many gaps in the ranks in consequence. M. de la Sauvagère, *officier du génie*, appears to have had curious notions of Roman castrametation; he supposes that these stones were erected "*pour servir d'appuis aux tentes et le mettre*

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* "Mr. Samms, in his "Britannia," will have the structure to have been *Phœnician*; Mr. Jones and Mr. Webb believe it to be *Roman*; Mr. Aubrey thinks it was *British*; and Dr. Charleton derives it from the *Danes*. And yet if the true old writing of the name be STAN-HENGEST, as the Monasticon seems to tell us, I cannot see, says Bishop Nicholson, why the Saxons may not have as just a title as any to the honour of it. There is a manuscript treatise said to have been written upon this subject by one Mr. John Gibbons, and 'tis possible this gentlemen may have a different notion from all the rest." —(Preface to "The Most Notable Antiquity of Great Britain, vulgarly called Stone-heng on Salisbury Plain.")

à l'abri du vent;" and the Comte de Caylus takes the trouble to produce a quantity of evidence that the Romans were not in the habit of encamping in such order. M. Mahé attributes all the megalithic monuments to the Hebrews and Greeks; whilst M. de Penhouet finds an identity between the name of Carnac in Brittany and Karnac at Thebes in Egypt; the same theorist also finds the Bas-Breton language as now spoken to be of a pure Phœnician origin. Dr. John Bathurst Deane saw here a temple in the form of an enormous serpent. This not very satisfactory hypothesis at one time found a supporter in Dr. Thurnam, who has, however, now given up this ophite or dracontium theory as untenable. At one time, indeed, such a reliable antiquary as Canon Jackson,[*] of Salisbury, believed in this ingenious invention of the highly-imaginative Stukeley. M. de Cambry would have the lines of Carnac to form an enormous astronomical calender ("un thême céleste, un zodiaque"), each line representing a sign, of which the ancient Gauls only (according to this theorist) recognised eleven; whilst others would have these and similar structures to be connected with astronomical observations; take, for instance, the following work published at Salisbury in 1771, entitled "Choir Gaur; the Grand Orrery of the Ancient Druids commonly called Stonehenge, astronomically explained and mathematically proved to be a Temple erected in the earliest ages for observing the motions of the Heavenly Bodies." Another astronomer (?), *anonymous*, by abstruse calculations backwards, ascertained that about 2000 years ago an occultation of one of the planets (also anonymous), must have taken place at such a point in the heavens as would have enabled an observer to view it through the celebrated cross stones of Stonehenge; his theory being that those cross stones were purposely so placed to fix the point of observation permanently, so that astronomers in after ages might be able to compare notes in their observations. Still later, Dr. Thurnam watched the rising of the sun from the altar stone where he stood, when it was seen to rise precisely over the top of the isolated stone, which is 10 feet high and about 200 feet distant from the entrance to the temple, apparently intended to direct the observation at the summer solstice to the point of the rising sun.

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[*] "In England of course attempts to solve the riddle of Carnac have not been lacking. One which has attracted much attention and support is, that it was a temple in the form of a serpent—a kind of building which (so the propounders of this doctrine told us) "the serpent worshippers or 'Ophites' used to construct, and to which they gave the name of 'Dracontium.'" A great deal of ingenuity and learning has been brought to bear upon this theory. I myself, "*faute de mieux*," used rather to acquiesce in it, depending wholly and entirely, as I did, upon the deliberate statements of its champions, that such structures *were made*, and that "*the ancients gave to them the name of Dracontium.*" Having never met in the course of my own limited classical reading with any thing or name of the kind, and beginning to wonder where any notice of it was to be found, I consulted one of the first Greek scholars of our day. He shook his head, and added that a Greek word with that meaning was to him unknown. I ransacked lexicon after lexicon, but no "serpent-temple," called by the ancients a Dracontium, was to be found. On further investigation it came to light that the word "Dracontium" was actually coined by an ingenious but rather extravagant antiquary, Dr. Stukely, as a name very suitable and convenient for a thing, which thing was also a creation of his own brain. Upon making this discovery I took leave of the Ophites.—Notes and Queries, 4th Series, Vol. iv., p. 3.

Latour d'Auvergne (le Premier Grenadier de France), in his "Origines Gauloises," was one of the first to refer these stones to a Celtic origin, in which supposition he is supported by Le Comte de Caylus, as well as by MM. Pelloutier, Mahé, and Déric. M. de Freminville, in company with Messrs. de Robien Borlase and Pallas, is inclined to the belief that these amorpholiths are the tombs of warriors slain in some memorable victory of exceptional consequence, perhaps erected by the Veneti (whose capital, Dariorig, is identical with Locmariaquer across the Crach river), and the isolated menhirs are supposed to indicate the graves of those slain at the outposts. M. L. Galles, in a memoir of the Departmental Archæological Society, quotes old Alaus Magnus (Archbishop of Upsal in 1546), who gives examples of the five different arrangements of these stone alignments; the translation of the passage is as follows:—"As to the obelisks or huge stones erected by the hands of giants and athletes, nowhere are they to be found more frequently than among the Ostrogoths, Westrogoths, and northern Suconi, where two or three roads meet, and as well in vast solitudes, which have long since been depopulated by plague, famine, and war, and which have not yet been restored to their former state of cultivation through the negligence or apathy of the inhabitants. These stones, erected in many places, have a length of 10, 20, or 30 feet, and a breadth of 4 or 6 feet. Their position is wonderful, their order still more wondrous, and their character most prodigious. In lines straight and long, they represent the contests of athletes; arranged in square, the *mêlée* of battle; in circle, the sepulchre of families; whilst if the lines form an angle, they represent an army of horse and foot, which either there or close by has triumphed over its enemies." So also there are other inadmissible opinions, which would make these stones to be memorials of the defeat of the Veneti* by Cæsar, or a cemetery of the same people, or a military trophy in honour of Hercules, or a grove of sacred oaks, and these great stones placed in lines like rows of trees. Mr. Yates has written to prove that these lines of stones are merely the result of agricultural operations by the clearance of natural boulders off the fields.

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* Mr. Fergusson's latest theory will be discussed in Part III.

There are not wanting, either, some who will not believe that these stones were placed by the hand of man, but think that all such remains as these in Brittany, and others, as Avebury in Wiltshire, are so many freaks of nature, which, by glacial or other means, has transported these masses from a distance, and scattered them as moraines or erratic boulders.

One of the most ingenious theories is that suggested by Canon Jackson, of Salisbury, in "Notes and Queries," July, 1869. He supposes the original number of the stones at Carnac to have been eleven thousand, and intended as a great national memorial of the eleven thousand British ladies who were wrecked, and perished on the coast of Armorica, in the year of our Lord 381. Mr. Lukis disposes of this presumed key to the rusty old lock, by showing that the number eleven has been assigned to the rows of stones at Carnac by careless observation, and that there are three groups of stones—one of ten, another of eleven, and one of thirteen rows.

Mr. Lukis, who (with his father, brother, and in company with Sir Henry Dryden) has made the amorpholiths of Finistère and the Morbihan his especial study for many years, has established the principal characteristic feature of these systems of avenues and enclosures as follows:—(*Vide* "The Stone Avenues of Carnac," a paper read at the Blackmore Museum, Salisbury, at the meeting of the Wiltshire Archæological Society, 1870, by the Rev. W. C. Lukis, M.A., F.S.A., Wath Rectory, Ripon.)

1. "The lines do not lie strictly east and west, but vary a little to the north and south."

2. "The narrow end is invariably eastward, and the head or wide part is toward the west end, and on elevated ground."

Referring to these features further on, Mr. Lukis remarks—"There is a feature which is common both to groups of rows of stones and to the sepulchres, which may help to throw some light on the subject, viz., their orientation. By far the larger number of the sepulchral monuments—those, I mean, which are usually termed dolmens—have their entrances between the east and south points of the compass, *i.e.*, nearly ninety per cent are so turned, which, it must be admitted, cannot be an accidental circumstance. So, too, the avenues are similarly orientated. If, therefore, the builders of the tombs had a religious reason for this arrangement, the same motive must have been dominant in the minds of the constructors of the avenues; and the inference is not without force, that the same people erected both. This arrangement may be a token of their religious reverence for the deified orbs of heaven, the sun and moon." —(P. 13 of Mr. Lukis's paper). To this we would add that this *orientation*, which is attributed to all these monuments, as regards the dolmens and tumuli, is well substantiated; but on looking at Mr. Vicars's map of the Carnac district in "Rude Stone Monuments," and the position of the stone avenues, we cannot fail to remark that the lines of Erdeven, St. Barbe, and St. Pierre, are nearly at right angles to those of Menec, Kervario, and Kerlescant; and again, that whilst the prevailing point of the entrances of the dolmens is south-east, the general direction of the three Carnac groups of alignments is considerably north of east. (Compare the points of compass given in table of the alignments.)

3. "The stones are always largest at the western termination, and of small size in the other direction. In the Menec and Erdeven groups, however, the stones slightly increase in size towards their commencement."

4. "Where there are circles connected with the lines, they are always at the large 'end.'"

5. "The circles are composed of stones differing in form from those of the lines. They are thin and wide, and not so tall as the tallest of the lines, averaging about 5 feet above ground."

6. "The stones of the circles nearly touch each other, whereas those of the lines have spaces of from 7 to 20 feet between them."

7. "The average distance between the lines at the west end is 30 feet, at the east end 18 feet."

8. "In no case is there, strictly speaking, an attachment of the circle to the lines."

Further, it appears probable to Mr. Lukis, "that the number of the lines in each series was determined at first, and the whole number begun at once." The size of the stones indicates this. Again, he presumes "that they were begun at the west end. Probably in all cases the circles were added last, at least after the wider or west portion of the series had been erected; because at St. Pierre, Quiberon, the circle is 77 yards on the south side of the lines, at Menec the centre of the circle is south of the direction of the central avenue, and at Kerlescant it is a large segment, and not a complete circle."

We do not quite follow Mr. Lukis in the last observations; for does not the separation of the circle from the head of the lines at St. Pierre rather intimate a certain independence of the two monuments? or again, perhaps, indicate a bi-fold arrangement, similar somewhat to that previously noticed in this paper as occurring, either accidentally or intentionally, at Kerlescant? Supposing that eight additional lines ran easterly from the St. Pierre circle, we should have an almost parallel example to those at Kerlescant and Menec.

The plan of the Kerlescant monument is evidently the most complete example remaining to us, exhibiting, besides its remarkable symmetry of design, an intelligible ending or finish, viz., a series of avenues terminating in a circle, close alongside of a smaller but similar series leading up to a sepulchral barrow. Nowhere else do we find complete circles, tumuli, and lines associated together. We meet with lines without circles (see the table, p. cxxv.), although traces of circles may yet be discovered in connection with them, but seldom circles without lines. Two instances alone of these latter are given by Mr. Lukis, one on the Ile aux Moines, and the other on the Ile El-Lanic; but as the sea has encroached on the south-east side of this latter island, so as to have washed away a considerable portion of the circle itself, some of the stones composing it being yet visible below low-water mark, so, probably, there formerly existed avenues leading to it.

IV. THE PUBLIC HEALTH ACT, 1872.

THE Act of Parliament bearing the above title, and dated the 10th August, 1872, is mainly an Act for the division of the county into sanitary districts, for the constitution of certain sanitary authorities, and for the transference to those authorities of all existing powers and obligations of a sanitary nature.

Clause 51 of this Act enacts that "every sanitary authority shall have power to direct the destruction of any bedding, clothing, or other articles which have been exposed to infection from any infectious disorder, and to give compensation for the same." With this solitary exception, the Act gives no explicit direction as to how the sanitary authorities are to conserve the health of the nation. In this respect it differs from the original Bill as first brought into Parliament. That, as will be remembered, contained a multitude of very minute, and in many respects arbitrary, clauses relative to the pollution of rivers. These clauses, which embodied the recommendations of the Royal Commission on the Pollution of Rivers, were abandoned by the Government as being altogether impracticable, and it is understood that the Government is about to make an end to the investigations of the Royal Commission, which have proved of so little utility to the state.

We will endeavour briefly to describe the provisions of the Public Health Act, which has just become the law of the land.

First, it does not apply to Scotland, nor to Ireland, nor to London. It applies exclusively to England outside the Metropolis.

All England, with the exception of the capital, is divided into sanitary districts, and these sanitary districts are of two kinds, viz., urban and rural. This Act constitutes *local sanitary authorities* in each of these districts, bearing the official title, "Urban Sanitary Authorities," or "Rural Sanitary Authorities." The Mayor, Aldermen, and Burgesses of a borough, or the Improvement Commissioners of a district, or the Local Board of a district, are constituted the urban sanitary authorities. In like manner the guardians of a rural union are constituted the rural sanitary authorities in rural sanitary districts.

It will thus be seen that this Act creates no new official body. It takes existing official bodies—the town councils of towns, and the poor law guardians of country places, and erects them into urban or rural sanitary authorities. The department of the central government of the country which is to preside over and regulate the action of the *local sanitary authorities* is the Local Government Board. Having fixed the sanitary authorities in the different districts, the Act proceeds to clothe them with authority, and to destroy that which was previously in existence, and which clashes with them. To these sanitary authorities revert all powers and duties exercised under the Local Government Acts, the Sewage Utilisation Acts, the Nuisances Removal Acts, the Common Lodging Houses Acts, the Artizans' and Labourers' Dwellings Act, the Diseases Prevention Act, and the Bakehouse Regulation Act.

The fourth section of the Artizans' and Labourers'

Dwellings Act, 1868, and the fourth section of the Sanitary Act, 1866, are repealed. The working of the "Alkali Act, 1863, and of the Metropolis Water Acts, 1852 and 1871, are confided to the Local Government Board (which, as we have said, presides over the sanitary authorities) by Clause 35 of the Public Health Act.

There are various enactments respecting the holding and acquisition of property by sanitary authorities, and respecting alterations of the areas occupied by sanitary authorities. These enactments, however, need not occupy our attention.

Clause 10 is very important. It enjoins on every sanitary authority the appointment of a legally qualified medical practitioner as medical officer of health in its district. It is further enacted that such appointment shall be made for a period not exceeding five years.

Clause 34 enacts that "the approval of the Local Government Board, and not that of one of Her Majesty's Principal Secretaries of State, shall be required for the appointment and removal of analysts under an act of the session, holden in the twenty-third and twenty-fourth years of the reign of Her Majesty, intituled 'An Act for preventing the Adulteration of Articles of Food or Drink.'"

The former of these enactments would seem to place the officer of health too much under local influence. It is most desirable, however, that this should not be so. If the medical officer of health or the chemist does his duty efficiently, he will often incur the opposition of wealthy persons who are local sanitary authorities. He ought by all means to be independent of them.

Intimately connected with the independence of these officers is the amount of salary which they are to receive. The duties of the medical officer of health are hardly compatible with his continuing to practise; and his salary ought, therefore, to compensate him for the abandonment of practice. It would, indeed, not be unwise, if the abandonment of active medical practice were made a condition of acceptance of office as a health officer under the Public Health Act.

It appears that nothing of this sort is in contemplation, but that the health officer is to be underpaid, and left to eke out his income as best he may. Under these circumstances, something like the following state of affairs may be expected to arise. A few high-minded men, who happen to be selected as health officers, will prefer what they deem to be the public interest, and sacrifice their own private advantage to it. These will suffer a species of martyrdom.

Others, again, of an opposite cast of mind, will manipulate their office so as to extend and develope their practice, sacrificing, if need be, every public consideration to that end. The vast majority, however, will simply recognise the fact, that to discharge the duties which are thrust upon them is impracticable, and will make no effort to do so.

This aspect of the case has, naturally enough, been discussed in medical circles. In particular, the British Medical Association has directed attention to it, and has pleaded for an allowance being made by the Chancellor of the Exchequer, in order to admit of adequate payment of the medical officers of health.

The Public Health Act, 1872, is admittedly only the prelude to an adequate Public Health Act. Let us hope that its successor will, at any rate, provide for the efficiency of the health officers and analysts.

V. ARTIFICIAL FLIGHT: AN AËRIAL SHIP.

IN continuing the record of what has been done, at home and abroad, to subjugate to man the dominions of the air, we must give attention to the most perfect of aërial machines yet constructed—the aërostat of M. Dupuy de Lôme. We have first to consider the extended study of the subject, in order to ascertain what had been done by others, and the causes of their failure, partially or in totality; this, too, with the necessity of collating the data from which conclusions might be drawn. The conception may be viewed as perfected, as a means to an end, during the siege of Paris, when many schemes of communication between the besieged and those interested in their trials were attempted. Out of many, the machine we are about to describe is that only in which the difficulties presented by an insufficiency of principle in the science of aërostation have been met. It is now our object to show in what manner these difficulties have been overcome.

Hydrogen gas was employed, and was obtained by the action of sulphuric acid and water on iron-turnings, the gas being afterwards washed and dried. The gas so obtained was calculated to exert an ascensional force of 735 to 1120 grms. per cubic metre, under an atmospheric pressure of 760 m.m. at the ordinary temperature. M. Troost, Professor at the Ecole Normale Supérieure, invented a varnish for the taffetas covering of the balloon which was found to be quite impervious to water. This varnish has gelatine for its base, and is prepared from two solutions, termed A and B respectively. A consists of 1 part of pure gelatine, 1 part of glycerine, 6 parts of pyroligneous acid. B consists of 1 part of tannin, and pyroligneous acid 6 parts. The glycerine is dissolved in the pyroligneous acid by the aid of gentle heat, and while warm A is poured into B, the mixture being stirred with a wooden spatula. The mixture is reheated in an open vessel for some time, acid being added as that in the mixture is evaporated. The balloon consists of white silk taffeta, lined with india-rubber, and again with nanzouk; and to the nanzouk lining the composition is applied.

M. de Lôme's attempt, although so eminently successful, cannot be characterised as ambitious, because, instead of depending upon speed for the hold of the machine upon the air, the object was the very modest one of giving to a balloon, of the best shape and dimensions, a velocity of about 8 kilometres with regard to the surrounding air. This being attained the same aërostat would, of course, when impelled by the wind, move at a more rapid rate; thus, with a fresh breeze, at the rate of 4 metres per second, the aërostat would be perfectly under command within an angle of 33° on each side of the wind's plane, or within a sector of 66°. And if we double the rate of movement of the wind, we must inversely halve the angles within which the aërostat may be considered safely under control. That the plane of movement shall be directly under the control of the aëronaut requires that much less resistance should be presented to the air than is the case with the ordinary balloon, and careful calculation led to the following dimensions:— Length, 36·12 metres (118 ft. 6 in.); diameter at centre, 14·84 metres (48 ft. 8 in.); the area of section through the centre being 172·96 square metres (1862 square feet), and the volume 3454 cubic metres (121,983 cubic feet). M. de Lôme, in his original paper, shows that to obtain a speed of 8 kilos. (about 5 miles per hour) it is necessary to maintain a motive power equivalent to 30 kilogrammetres (or 217 foot-pounds) per second, this motive power being preferably obtained from manual labour utilised in rotating a shaft to which is attached a two-bladed screw. In this case, if we take R to represent the resistance of the atmosphere at a speed, *s*, of the balloon in seconds, *d* the diameter of the screw, *p* the pitch of the screw, and *n* the number of revolutions per minute, then

$$\frac{pn}{60} = (1+a)\,s\,;$$

and the work of the screw per second will be—

$$\mathrm{R}\frac{pn}{60} = (1+a)\,\mathrm{R}s.$$

Consequently the amount of work required to move the aërostat is the last quantity plus the amount lost as friction. The numerical examples quoted by M. Emile Leclert, Architect of the French Navy, in a recent admirable article contributed to "Naval Science," will here suit our purpose. He shows that the resistance of a thin plane being taken equal to 0·665 kilogramme per square metre (14 lbs. per square foot) for a speed of 2·22 metres (7·25 feet), the resistance of the balloon alone may be estimated at 6 kilogrammes (1·23 lbs. per square foot), and of the entire machine at 11 kilos. (2·25 lbs. per square foot). With the values d = 9 metres (29½ feet), p = 8 metres (26¼ feet), fraction of speed of each blade at the extremity 1-16th, and at the centre of action 1-10th, the theory of the screw leads to the conclusion that $a = 0{\cdot}26$. From this conclusion values are obtained for n and T, giving as a result that for a speed of 2·22 metres per second, or 8 kilometres (5 English miles) per hour, the labour of 4 men in turning the winch is necessary, and 8 men for a speed of 2·22 metres $+ \sqrt[3]{2} = 2{\cdot}80$ metres per second, or 10 kilometres or 6¼ miles per hour. These numerical results are quite opposed to the conditions required by Navier's theory,* being a much smaller number of men.

M. Dupuy de Lôme has found that a balloon to be successfully navigated must always be maintained at an equal degree of inflation, in order that the resistance to which the balloon is exposed in its passage through the air should remain constant, and capable at any moment of being defined. The balloon, at starting, being inflated fully with hydrogen, the constant degree of inflation is preserved by means of the hanging-tubes, H H, Fig. 2. These tubes have the ends open, and are pendant about 25 feet below the balloon. As the gas expands it forces itself down these tubes, while its own pressure in the tube reacts upon the body of gas in the balloon, preserving such an excess of interior pressure as prevents the shape of the outer covering being altered by the force of the wind. Still further to maintain a constant surface there is provided a small internal balloon (termed a *ballonnet*), which, as the gas escapes, through diminution of pressure, from the primary balloon, can be filled with air. As the gas expands in the larger balloon it would be forced out of the pendant tubes, were it not that a valve, opening at a low pressure, is attached to the ballonnet. The

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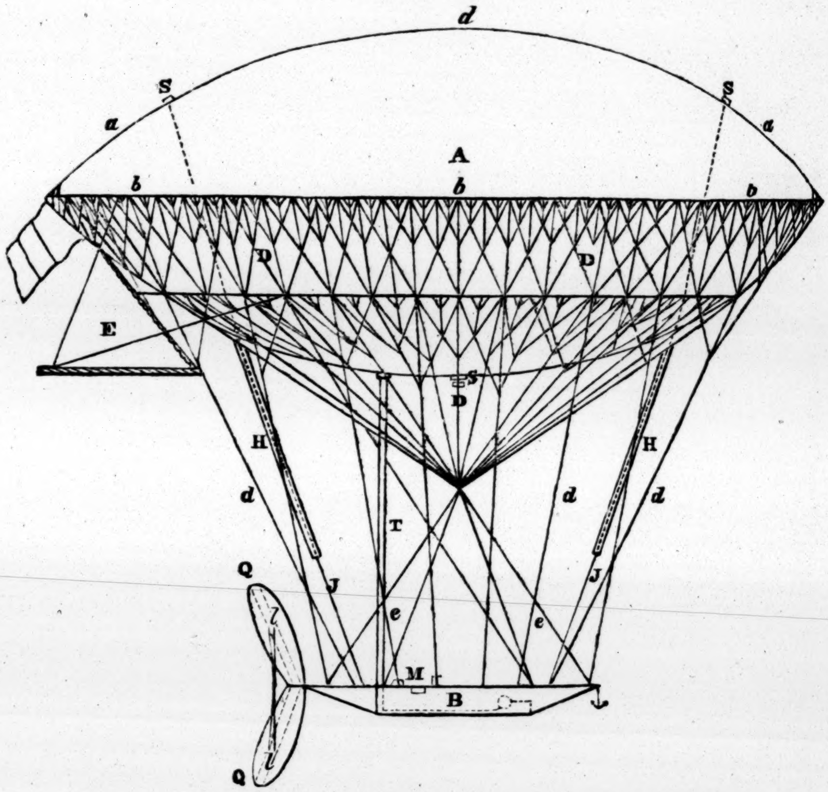
* Memoires de l'Institut de France, vol. xi.

FIG. 1.



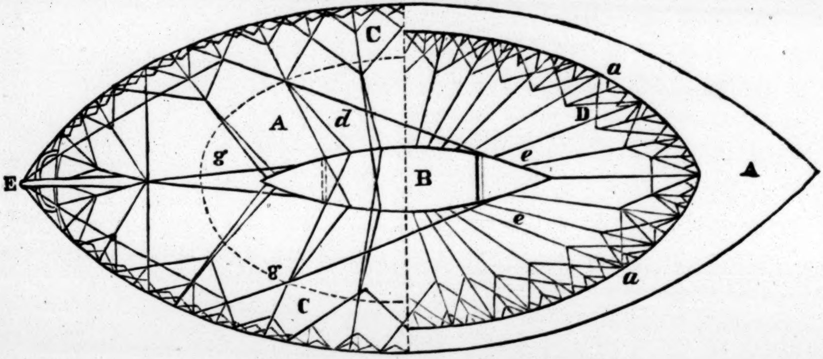
FIGS. 1, 2, 3. A, the balloon; B, the car, with D, the net-work; *a a*, taffetas covering; *b b*, collar attaching the upper netting to the covering of balloon; *d d*, silken ropes suspending the car; *e e*, balance ropes for the car; *f*, small internal balloon; *g g*, line of intersection of the surface of the balloon with that of small internal balloon; E, gaff-sail, or rudder; H, pendant tubes, the length of which regulate height of the column of hydrogen; J, the cords regulating the valves S; T, tube for filling small balloon with air; M, crank for working the screw, Q; *l*, stays, strengthening the screw.

ultimate proportions of the aërostat, as given by M. Dupuy de Lôme, are—

Height from top of balloon to keel of car = 29·12 metres (95½ feet).
Distance between screw shaft and major axis of balloon = 20·45 metres (67·1 feet).
Distance of major axis from centre of gravity of complete machine (without ballast) = 15·54 metres (51 feet).
The rudder is a triangular sail of 15 square metres (161½ square feet) area, manipulated by cords from the car.

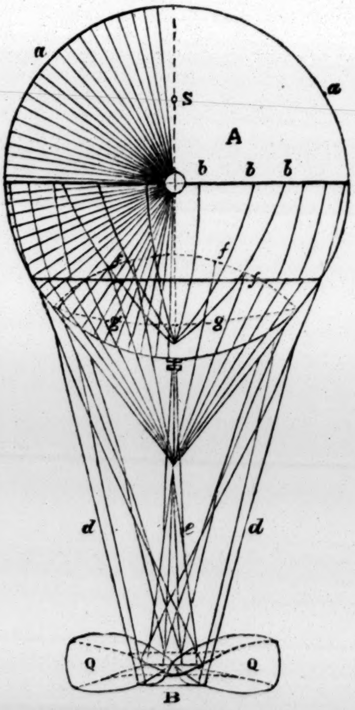
We come now to the description of the journey actually undertaken in this machine, premising that instances of so complete a fulfilment of calculation are very rarely occurrent.

FIG. 2.



The ascent took place from the Fort Neuf of Vincennes. The crew consisted of 14 men, with baggage and provisions weighing 1·13 tons. There were on board MM. Dupuy de Lôme, Zédé (Ingénieur de la Marine), Yon, and Dartois, aëronauts. The instruments weighed 1·75 tons, and there were 0·27 ton of packages to be carried to the destination of

FIG. 3.



the balloon. The total weight, with 0·59 ton of available ballast, amounted to 3·74 tons, and the balloon, when thus ballasted, had an ascensional force sufficient to keep it in equilibrium close to the ground. In the first ascent 3 cwts. of ballast were thrown out, the balloon rising from the earth on February 2, 1872, at 1 o'clock. From 1 o'clock to about a quarter past but little more was done than to admire the graceful evolutions of the machine, and the readiness with which it answered to both helm and screw. At 1 h. 15 m. observations were commenced, and showed the car to be 560 metres (1837 feet) above the departure station, and moving in a north-easterly direction with a speed of 12 metres (39 feet) per second. The course was then altered to the south-east, at an angle of 83°, with the former direction. The number of men working the screw, at 25 revolutions per minute, was eight, the aërostat moving with regard to the earth at a speed of 16 metres (or 52·5 feet) per second. Afterwards this speed increased, with 27·5 revolutions of the screw per minute, to 17 metres (55·8 feet) per second. The speeds given by the form of anemometer employed, as due to the balloon, or rather to the screw, were 2·35 metres (7·7 feet) to 2·82 metres (9·3 feet). The descent was commenced at 2 h. 35 m., and was effected at the destination, Mondecourt, near Noyon, without any shock or the slightest accident.

We should now consider the results that have been attained in the experiments with the aërostat. They are—the maintenance of a constant exterior surface by means of the ballonnet; freedom from rocking motion, even while two or three persons are walking in the car; and a perfect control, the head of the aërostat being shifted to or kept in any direction, with a maximum force of 60 kilos. from the manual labour of the eight men.

These are the mechanical improvements that have been achieved, but the most important result is that an impetus will be given to the study of aërial navigation now that the science has found a theory seldom paralleled in its application. The remark of one of our greatest men, "Impossible; I don't know the word," has indeed been practically shown to be an admitted principle by M. de Lôme.

M. de Lôme further proposes to remove seven of the eight men employed to work the screw, and substitute an engine of eight-horse power, with one man as engineer. The ballast would then consist of the fuel and water, while the aërostat could be impelled at the rate of 14 miles per hour, at a much larger angle, with the plane of direction of the wind. There has thus now been opened to us a new path in the science of aërostation, and it is difficult to limit the imagination to those new wonders we may expect within even a few more years.

VI. PAPER AT THE INTERNATIONAL EXHIBITION.

By F. C. Danvers, Assoc. Inst. C.E.

THE International Exhibition of 1872 is the second of the series of annual International Exhibitions held at South Kensington. These Exhibitions, which will henceforth take the place of their larger prototypes, so far at least as this country is concerned, shall, it is intended, be opened each year for the exhibition of special industries, each in their turn. Last year, the classes to which the Exhibition was confined were mainly three—the fine arts, pottery, and woollen and worsted fabrics. This year, again, it also consists of three main divisions—fine arts, manufactures of cotton and cotton fabrics, articles of jewellery worn as personal ornaments, paper and stationery. Printing also occupies a prominent position, whilst musical instruments of all kinds and acoustic apparatus are also represented. The third division consists of scientific inventions and new discoveries.

A notice of the principal exhibits classed under the third division appeared in the last number of the "Quarterly Journal of Science," and we shall not, therefore, refer further to them now. The fine arts division we shall also upon the present occasion leave unnoticed; and as within the limits of a single article it would be impossible to do justice to all the manufactures classified, we purpose to confine ourselves to those which occupy the most prominent part of the Exhibition, namely, cotton and cotton fabrics (so far as they may be said to be connected with paper manufacture), paper, and stationery.

In respect of the exhibits which form the subject of our present article, it cannot be said that there is a very satisfactory show, foreign countries especially being hardly, if at all, represented by specimens of paper manufacture. This subject has been very much neglected on former occasions, there having been only eleven exhibitors from Great Britain in both the Exhibitions of 1851 and 1862. Nevertheless, it cannot be denied that paper forms a most important industry, especially in this country, and is capable of being applied to a number of purposes with great advantage, where other and more expensive materials are now principally used. In the present article we shall not, therefore, strictly confine ourselves to a notice of what is presented to the public eye at this year's International Exhibition, but we propose to extend our review so far as to notice other uses of paper which are not shown there, and, as a fitting introduction to our subject, a brief history of paper manufacture may well precede our further remarks on the subject.

Without going back so far as to the earliest periods, when the only means of recording events were by engraving in clay, stone, and metals, which were used by the ancients for all matters of public notoriety; and passing by the subsequent use of thin slices of wood, and skins of animals for similar purposes, we shall come at once to consider the use of those materials whence we may trace the origin of paper manufacture from vegetable substances. Thus, then, it would appear that the use of boards was in some measure superseded by that of the bark and leaves of certain trees, and it is from the latter that the first paper was manufactured. The plant whose leaves were mostly used for writing on was the *Papyrus*, a kind of large rush, which grew upon the banks of the Nile. At a very early period the Egyptians appear to have manufactured a species of paper from its leaves, or, as some suppose, from the stock of the plant. It is uncertain when the use of the *Papyrus* leaf was superseded by paper made from it; but Egypt enjoys the honour of having invented the process, and Isidore even fixes the locality of its first manufacture at Memphis. Varo, the Roman, ascribes the date to the time of Alexander the Great, after the founding of Alexandria; but Pliny quotes a passage from the writings of Cassius Hemina, an ancient annalist, in which he speaks of some books found in the tomb of Numa, when it was opened 535 years after his decease, and asserts that these books were of *paper*, and had been interred with him. As Numa preceded Alexander by 300 years, this circumstance, if admitted, would carry back the date of the invention anterior to that time. Dr. Gill, in his Commentary, says, "On the banks of the Nile grew a reed, or rush, called by the Greeks *papyrus*, or *byblus*, from whence come the words *paper* and *bible*, or book, of which paper was anciently made, even as early as the time of Isaiah." This, then, if correct, would take the manufacture back to a still earlier date.

Egypt long had the monopoly of the manufacture of papyrus paper, and at the time of Augustus the trade was considerable, not only at Rome, but throughout the world. In the ninth century, the use of papyrus made in Egypt ceased in Europe, and it was replaced, almost universally, by paper made of cotton from the East.

It is a curious circumstance, that there is at the present day no plant known to botanists which corresponds exactly with the papyrus of ancient times. In the prophecy of Isaiah a very remarkable prediction occurs with reference to this plant, in the following words:—"The paper reeds by the brooks, by the mouth of the brooks, and everything sown by the brooks, shall wither, be driven away, and be no more." So far as the papyrus plant is concerned, that prophecy appears to have received an actual fulfilment.

The art of making paper from vegetable fibre, reduced in water to a pulp, is said to have originated in China. The oldest known records in that country are inscribed on very thin slips of bamboo, carefully dried by artificial heat, and many of these are preserved in the pagodas. At a later period the Chinese made use of a peculiar kind of silk, called silk paper; and finally, both were replaced by an inventor named Tsaï-lun, who made use of the bark of certain trees, hemp, rags, old nets, &c., which he boiled down to a pulp, and thus produced paper proper. According to different authorities, this invention dates from between A.D. 89 and 105, whilst by another it is stated that the results of this invention were presented to the Emperor of China about the year A.D. 153.

The manufacture of paper from the paper mulberry (*Broussonetia papyrifera*) was introduced into Japan about A.D. 610. Up to the year A.D. 280, silk, with a facing of linen, was used for writing upon, and thin wood shavings were also employed. In that year, however, paper was imported from the Corea; and this appears to have been the only paper known to the Japanese until the year 610, when two priests named Douchô and Hâjô were sent over to Japan by the King of the Corea. Douchô is said to have been a clever man, learned in the Chinese classics, and, moreover, a skilful artist. Besides the manufacture of paper, he also introduced that of writing-ink and millstones into the country. Although the paper made by Douchô was very good of its kind, it did not take ink well, and had, besides, other drawbacks. In consequence of this, Shôtoki Taishi, a son of the reigning Mikado, who had learned paper-making of Douchô, introduced the manufacture of paper out of the paper mulberry, which plant he caused to be extensively planted all over the country, and the mode of paper manufacture to be largely promulgated among the people.

Some time in the seventh century the art of paper-making became also known to the Persians, and about the year 700 it passed into Arabia. The Arabs carried the knowledge into Europe in the earlier half of the twelfth century, and established a paper manufactory in Spain. Upon the authority of Edresi, who wrote in 1150, a paper was then made at Xativa, an ancient city of Valencia, equalled by none produced elsewhere, and which was extensively exported to the East and West. From Spain the art extended into France, in which country, as well as in Italy, there existed paper factories at the commencement of the fourteenth century. In Germany, too, a paper factory was established at Nuremberg, in 1390, by Ulman Stromer, who also wrote the first work ever published on the art of paper-making.

Paper made from cotton became general at the close of the twelfth and the beginning of the thirteenth centuries, but in the fourteenth century it was almost entirely superseded by paper made of hemp and linen rags. English manuscripts on linen paper date as early as 1340, but it is believed that the manufacture did not exist here until the end of the fifteenth century: indeed, the earliest trace of the manufacture in this country occurs in the *Bartolomæus* of Wynkyn de Worde, printed in 1496 by Caxton, in which it is said of John Tate, jun., whose mills were at Stevenage, Hertfordshire,—

> "Which late hathe in England doo make thys paper thynne
> That now in our Englyssh thys booke is prynted inne."

In 1858 Sir John Spielman, a German, established a paper mill at Dartford, for which the honour of knighthood was conferred upon him by Queen Elizabeth, who was also pleased to grant him a license "for the sole gathering for ten years of all rags, &c., necessary for the making of such paper."

It is recorded in the "Craftsman," that William the Third granted the Huguenots, who brought with them many of the improvements which France had introduced into the manufacture, a patent for establishing paper manufactories, and that Parliament likewise granted them other privileges.

For a long time England imported almost all its paper from France. Although the manufacture was introduced at the end of the fifteenth century, scarcely any but wrapping-paper was made in this country before the Revolution, but the manufacture afterwards advanced so rapidly, that by 1760 Britain was almost wholly independent of foreign supply. In that year James Whatman, who had learned the art of paper-making whilst travelling in the suite of the British ambassador to Holland, where the best papers were then made, established a paper factory at Maidstone. Not long before this wove moulds had been invented by Baskerville, to obviate the usual roughness of laid paper.

Paper was made entirely by hand until about the year 1803, when M. Didot, a Frenchman, brought over to this country a model of a continuous machine, which was taken up by Messrs. Fourdrinier, at that time the principal stationers and paper manufacturers in Great Britain, and it was perfected and manufactured by Mr. Bryan Donkin, whose firm are, at the present day, the principal manufacturers of paper machinery in the United Kingdom. In 1809 Mr. Dickinson, a paper maker, invented another method of making endless paper; and in 1826 M. Canson, of Annonay, first applied suction-pumps to the Didot and Fourdrinier machines.

The principle of paper-making machinery is simply this: instead of employing moulds and felts of limited dimensions, as was originally the practice, the peculiar merit of the invention consists in the adaptation of an endless wire gauze to receive the paper pulp, and again an endless felt, to which in progress the paper is transferred, and thus, by a marvellously delicate adjustment, while the wire at one end receives a constant flow of liquid pulp, in the course of two or three minutes there comes out at the other end of the machine a continuous length of paper carefully wound upon a roller.

Having thus briefly recorded the history of paper manufacture, we pass on now to a consideration of the different materials from which it is made; and, first of all, we will refer to the raw products, as shown in the International Exhibition. First of all, then, we must notice the cotton exhibits, as, so far as we at present know, it was from the raw cotton that paper was first manufactured, and, as has been already stated, this manufacture had its origin in China.

Various specimens of the cotton plant are exhibited, growing in pots, with their cotton pods fully developed, in a separate building or conservatory, called the "Cotton-growing House," in the west grounds of the Exhibition building, where many varieties of Indian, Egyptian, American, Chinese, and other cottons may be studied in their natural state. In Room I. in the west galleries, close by, the further development of cotton through the various stages of ginning, blowing, making into laps, carding, breaking, finishing, drawing, slubbing, roving, the mule, and weaving-looms, are all successively shown, most of the machines being exhibited in actual work, whilst cases along the side walls contain specimens of almost all the known species of cotton in their raw state, accompanied, in some instances, with specimens of the manufactured article, in all the various stages through which it passes before arriving in the perfect state in what it is known as "cotton goods." The seeds of some species of cotton, after ginning, have a certain quantity of short cotton fibre adhering to them. This is carefully cleaned, and the "cotton waste" so obtained used for paper manufacture. The other principal materials employed in the production of paper in the various provinces of China are hemp, the young shoots of the bamboo, the mulberry-tree, the rattan, sea-weed, rice and wheat straw, silk cocoons, the bark of the *Broussonetia papyrifera*, and the pith of the *Aralia papyrifera*, from which the celebrated Chinese rice-paper is made. In Japan, the principal plant from which paper is manufactured is the *Broussonetia papyrifera*, or paper mulberry. Another plant, known as the *Toroto*, which grows not unlike the cotton plant, yields a paper fibre from its root, but neither the flower nor the seed are of any use for the purpose. There are also the *Makoso*, or paper plant, the *Kajiso*, and the *takaso*, used for paper of an inferior quality.

The following is a list of the Indian fibres used for paper-making, samples of which are all exhibited together with, in most cases, samples of paper made from them.

Punjab Flax, *Linum usitatissimum.*
Rheea, *Bœhmeria nivea.*
Puya Bark, *Bœhmeria puya.*
Puya Fibre, *Bœhmeria puya.*
Nilgiri Nettle, *Urtica heterophylla.*
Mudar, *Calotropsis gigantea.*
Bedolee Sutta, *Pæderia fœtida.*
Jute, *Corchorus olitorius.*
Sufet Bariala, *Sida rhomboidea.*
Ambaree, *Hibiscus cannabinus.*
Roselle, *Hibiscus sabdariffa.*
Indian Mallow, *Abutilon indicum.*
Bun Okra, *Urena lobata.*
Himalayan Hemp, *Cannabis sativa.*
Sunn Hemp, *Crotalaria juncea.*
Jubbulpore Hemp, *Crotalaria tenuifolia.*
Dunchee, *Sesbania aculeata.*
Pine Apple Fibre, *Ananassa sativa.*
Marool, *Sanseviera zeylamca.*
Agave, *Agave americana.*
Great Aloe, *Fourcroya gigantea.*
Adam's nettle, *Yucca gloriosa.*
Plantain, *Musa paradisiaca.*
Screw Pine, *Pandanus odoratissimus.*
Red Bast, from Pegu.
Shaw Nee, Shaw Young, Shaw Laybway, and That Pootnet Shaw, all from Burmah.
Nepal Paper Shrub, *Daphne cannabina.*

Besides the above, there are also exhibited samples of Indian paper made from gunny bags, refuse gunny, fishing nets, old records, and bamboo.

From the Report of the New York Industrial Exhibition of 1853, it appears that the materials principally used in America for paper-making are raw cotton and cotton waste. Linen rags are imported from Europe, but the principal consumption would appear to be cotton, either as above named or in rags. Sir William Hooker, in his Report on Vegetable Products at the Paris Exhibition of 1855, gives an exhaustive list of fibres produced in different countries, many of which are used for paper-making. It would occupy too much space to insert their names here, and we have therefore contented ourselves with pointing out where such information may be obtained.

The Indian, Chinese, and Japanese are by far the most perfect collections of paper-making materials in the Exhibition, and we have therefore given greater prominence to the products of those countries. Queensland shows a specimen of the *Sida retusa*, an indigenous weed, the fibre of which is used as a substitute for flax, and the refuse makes pulp for paper. Many of the exhibitors show specimens of the Esparto grass, both Spanish and Algerian, from which paper is now largely made, also of straw and straw pulps, as well as of pine wood. One case exhibited by F. B. Houghton shows all the different stages through which pine wood passes from the rough block to paper pulp; whilst another exhibitor, P. L. Simmonds, shows the various processes for reducing the waste from cotton seeds, and rough pine wood and bamboo, to the consistency of paper pulp.

In passing now from a consideration of the different raw materials used in paper-making, the next step is to review briefly the various processes employed in paper manufacture. Up to a certain point these processes necessarily vary with different materials beyond which the same kind of machinery may be employed. According to the nature of the raw materials different treatments must be observed in reducing them to a pulp, but after that stage has been reached the remainder of the manufacture may be generally said to be the same. We shall, therefore, first briefly notice the machine for manufacturing the pulp into paper, and then give a short account of how some of the raw materials are first reduced to a state of pulp.

There are two excellent models of paper-making machines respectively on scales of ⅛th and ¼th full size, exhibited by

Messrs. B. Donkin and Co., of London, and by Messrs. G. Bertram and Co., of Edinburgh.

The pulp, when sufficiently ground, descends into a reservoir, in which it is kept constantly agitated in water. From this reservoir the pulp passes into a trough, where it is strained by means of a sieve, or "knotter," as it is called, the under part of which communicates with an exhaust pump in order to facilitate the passage of the pulp through the fine meshes of the "knotter." Passing from the strainer, the pulp is next distributed equally throughout the entire width of the machine, and is afterwards allowed to flow over a lip or ledge in a regular and even stream, whence it is received by the upper surface of an endless woven wire band, upon which the first process of manufacture takes place. This wire band, as it travels forward, has also a gentle vibratory motion given to it in order to assist the pulp to spread evenly over its surface, and to facilitate the separation of the water, which latter is also further aided by the action of a suction pump beneath, and thus the pulp solidifies as it advances. The width of the paper is regulated by deckle or boundary straps, which travel at the same rate as the wire gauze, and so limit the spread of the pulp.

The partially solidified pulp now passes under the "dandy" roller, which is employed to give any impression to the paper that may be required, and in forming what is called the "watermark," to which we shall presently refer more fully. The paper then passes under two "couching" rollers, which are simply wooden rollers covered with felt. Merging from these the paper is received from the wire gauze by a continuous felt, which conducts it through two pairs of pressing rollers, and afterwards to the drying cylinders, which are heated internally with steam. The paper, after passing over these cylinders, is finally wound upon a reel. For the finer sorts of paper, and especially for writing paper, a subsequent process of sizing must be undergone, which in most cases is effected continuously with the manufacture of the paper, and before it is finally wound.

To convey some idea of the number of substances which have been really tried for paper making, it may be stated that in the library of the British Museum may be seen a book, printed in low Dutch, containing upwards of sixty specimens of paper, made of different materials, the result of one man's experiments alone, so far back as the year 1772. In fact, almost every species of tough fibrous vegetable, and even animal substance, has at one time or another been tried. Cotton in its raw state requires far less preparation than a strong hempen fabric, and thus, to meet the requirements of the paper-maker, rags are classed under different denominations, as, for instance, *Fines*, *Seconds*, *Thirds* (composed of fustians, corduroy, and similar fabrics), and *Stamps* on *Prints*, as they are termed by the paper-maker, which are coloured rags, distinguished by certain well-known marks, indicating their various peculiarities. Samples of these may all be seen in cases exhibited by Messrs. John Dickinson and Co., and Messrs. T. H. Saunders, together with specimens of the different chemicals used in paper manufacture, and of the various colouring matters employed.

The first process necessary is to examine the rags, open all seams, remove dirt, pins, needles, buttons, &c., which would be liable to injure the machinery or to damage the paper. The rags are then cut in small pieces, mostly by hand, and sorted according to their quality. A machine for cutting rags, jute, hemp, &c., is exhibited by Messrs. B. Donkin and Co., and when this is used, sorting the rags necessarily precedes the operation of cutting.

After cutting the rags are removed to a dusting machine, in which all the dust and dirt contained in them is knocked out. They are then boiled in an alkaline ley or solution, made more or less strong as the rags are more or less coloured, the object being to get rid of the remaining dirt and some of the colouring matter. The mode of performing this is by placing the rags in large cylinders, which are constantly, though slowly, revolving, thus causing the rags to be as frequently turned over, and into which a jet of steam is cast. A large spherical boiler used for this purpose is shown by Messrs. B. Donkin and Co. The rags now pass into the comminuting machine, in which they are ground into pulp, and afterwards the mass is conducted into another engine, where, if necessary, it is bleached by an admixture of chloride of lime. The pulp is then let down into large cisterns to steep, prior to being reduced to a suitable consistency by a heating engine, after which it is conducted to the paper-making machine, as has been already described.

Before passing on to notice various uses to which paper is applied, a short space may be advantageously devoted to giving an account of some special manufactures. For this purpose we shall confine ourselves to a few only of the most interesting.

The well-known rice-paper of the Chinese is obtained from the pith of the *Aralia papyrifera*, a plant allied to the

Artocarpus, or bread-fruit tree. The pith is carefully taken out, cut into sheets, and smoothed with an iron preparatory to use.

The most important paper made in China is that from the bamboo. In the month of June the bamboos, which are on the point of producing new shoots, are cut down and divided into lengths of 6 or 7 feet each. These pieces are placed in a pit dug in the earth, and kept full of water, and remain there for one hundred days or more; they are then beaten with a mallet to remove the green bark which covers their surface. The bamboo, thus prepared, is boiled in a large wooden vessel full of water containing slaked lime, and placed within a metal boiler. The fire is generally kept up for eight days, and at the expiration of that time the fibres are taken out and carefully washed; they are afterwards plunged in a ley made from wood ashes, and then laid in a boiler covered an inch thick with ashes from burnt rice-straw, when water is added, and the whole is boiled; these last operations are repeated in rotation during ten days. By this time the fibres begin to rot, and they are then pounded in large mortars, the stampers or pestles being generally moved by water-power in a very simple manner. When reduced to pulp, it is placed in vats, and a liquid added, which is supposed to contain chlorine to whiten the mass. The sheets of paper are formed in the same manner as hand-made paper in Europe, but the frame is composed of woven fibres of the bamboo instead of wire; when formed the sheets are laid one upon another upon a table, till a heap of about a thousand is produced, when a plank is laid on the top, and pressed down with great force by means of cords passed round the table, and the paper is left to drain. The drying is achieved by placing the sheets, one by one, by means of a brush, on the outer surfaces of a hot stove built of brick.

Some of the Chinese, and especially the Corean papers, are smooth on both sides; this dress is produced by first polishing the surface with dried leaves, and afterwards pressing it by means of heavy rollers moved by hand.

The manufacture of paper from the *Broussonetia papyrifera*, or paper mulberry, is thus conducted by the Japanese:—The mulberry stalks are cut into lengths of 2½ to 3 feet, which are then steamed in a vessel made of straw until the skin begins to separate at the cut ends. The skins are then stripped off by hand and dried, the stripped sticks being used as firewood. The drying is effected by hanging them over transverse poles in the open air. After drying they are weighed into portions of about 32 lbs. each, and tied up in bundles. They are then washed in running water, in which they are left for a day and a night, after which they are taken in, and the inner fibre separated from the outer skin. The outer dark skin is then scraped off with a knife, and is used for making an inferior kind of paper; it is called "Saru-Rawa," and after being thoroughly washed in running water, which causes it to open out flat, it is boiled. It is then allowed to rot, and is well beaten, after which paper is made of it.

It usually takes two or three days to make paper from the inner bark. Tied into bundles of about 32 lbs. weight each, it is taken to the river and thoroughly washed, and afterwards steeped in buckets of water; the water is then run off, and heavy stones placed on the fibre to express the remaining liquid; they are then boiled in water infused with the ashes of burnt buckwheat husks. It is afterwards placed in a basket, and boiled a second time to get rid of the ash infusion. After a third washing it is placed in a wooden vessel and pounded into pulp. It is then mixed with a paste made from boiling the roots of the *Tororo* plant, and formed into sheets by hand moulds, and then dried in the open air, except in wet weather, when it is sometimes dried by the heat of a fire.

Paper manufacture from pine wood is extensively carried out in Sweden, and the use of that fibre is, it is believed, largely on the increase in this country. After the particulars already given of the means employed for reducing fibres to pulp, all that is necessary, in referring to the use of pine wood on the present occasion, is to point out the principal difficulties experienced in its use, and the manner in which those difficulties have now been overcome. The almost inexhaustible supply of this material would naturally commend itself to paper-makers; but the obstacles to its extended employment arose from the large quantity of alkali necessary for disintegrating the fibre, and the necessity for very strong vessels in which to perform the operation, because it is only by boiling at a high temperature with a solution of caustic soda that this can be performed. These two difficulties have now been successfully overcome; that with regard to safe boilers by means of a process invented by Mr. F. B. Houghton, which dispenses with the use of fire under the boiler, and the expensiveness of caustic soda is avoided by employing the process discovered by M. Tessie du Motay, by which the tedious and expensive process of evaporation and calcination, which had only for its object the destruction of the resinous matters taken from the wood, is now performed without evaporation or calcination, by simply passing a current of gas through the liquor which has been employed for boiling the wood; this separates the resin from the liquor, leaving it floating in it. It is then coagulated and falls to the bottom, and the liquor can then be treated as if it were new soda-ash. Finally, the resin, instead of proving an obstacle, becomes a source of revenue more than sufficient to pay all the expenses.

We must now briefly notice some of the manufactures of which paper forms the basis. The one most completely illustrated in the Exhibition is the manufacture of envelopes, by Messrs. John Dickinson and Co. The paper, as it arrives from the mill, each of about three-quarters of a mile in length, in rolls, is fixed to the cutting-machine. The sheet is first cut longitudinally by two circular cutters, working, like scissors, on each other. It is then cut transversely by a revolving knife at the end of the machine, and which is so arranged that sheets of any required size can be cut by it. The paper, on leaving this machine, is too rough for writing purposes, and has next to be "glazed." This is done by interleaving it, sheet by sheet, with plates of zinc or brass, and passing it in small quantities between rolls, under a pressure varying from 20 to 40 tons. The paper is then put in bundles of sheets under a punching-machine, which cuts out the "blanks." These have to be gummed on "the nose," that is, on that portion which has to be wetted when fastening the finished envelope. The girls who are employed on this work can gum some 4000 per hour. The blanks are then put into a chamber of racks, heated by steam, in order to dry the gum. The next process is the stamping, which is done by hand under a small ball-press; and at this point the process of black-bordering, when required, is carried out. This is also done by hand, the blanks being arranged in a row overlapping each other, so as to leave a width of each uncovered equal only to the width of the desired border. The blacking is then done by hand, by means of a brush; two edges only can be blacked at once, and when dry the other two edges are done in a similar manner.

The blanks thus finished are placed by parcels into a folding-machine—of which there are several different kinds shown at work in the Exhibition—which folds and gums up the envelopes entirely automatically. The finished envelopes are then banded in packets of twenty-five, the defective ones being thrown out. Ten of these packets are then sealed up together and labelled. The black-bordered envelopes are packed in boxes, each box containing one gross.

The Waterproof-Paper and Corrugated Fibre Company exhibit specimens of their manufactures, paper and other fibrous materials being waterproofed by the solvent action of cupro-ammonia. By the agglutinising property of the same fluid, combinations of cotton or linen fabrics are made with waterproof-paper. This material is manufactured in slabs, flat or corrugated, of various thicknesses, for roofing and building purposes, waterproof-tubing, panels, and so forth.

Messrs. Pavy, Pretto, and Co. exhibit, all over the building, elegant curtains made from paper, of very elegant appearance, and which can be sold at a price so moderate as to place them within the reach of all.

The material employed is called "felted fabric." It is not a real tissue, but rather a species of Japanese paper, remarkable chiefly for its texture, being firm and tough, yet pliable. In point of durability it must compare favourably with most other materials used for similar purposes, inasmuch as the colours with which it is printed are indelible, and do not fade under the effects of sunshine, damp, or dust. It is impermeable, light and warm for quilts and curtains, and needs no washing. The fibres used in this manufacture are subjected, under the influence of heat and pressure, to very perfect operations of chemical disaggregation, and comminution by mechanical treatment; it is then washed in alkaline and antiseptic baths, crushed under ponderous cylinders, and then desiccated and bleached by the sulphurous gas; it is then further washed, and the fibres disintegrated by grooved cylinders, pulped in poachers, and finally felted in a paper-machine modified for the special requirements of the manufacture.

From Sweden there is a case exhibited, showing several different uses to which pasteboard is applied in that country. It is made from a mixture of straw and rags:—

Yellow pasteboard, as it is called, is applied on the inner part of the walls of a house to protect the hangings.
Grey rag pasteboard, which apparently contains a mixture of grey ragstone, is used for floorings.
Raw pasteboard, of which is formed asphalte and roofing.
Tarred pasteboard, employed to keep out draught and moisture in buildings.
Asphalte roofing pasteboard.

In China paper is often used in the place of glass for windows. This is mostly made in the Corea, and is often of large size, and as strong as a thick fabric. It is generally rough, but sometimes well-glazed, in which case it is worth sixpence or more per square yard. This paper is submitted to the action of steam, and then dressed with a mixture formed of oils of *Sterculia tomentosa* and of hemp-seed, mixed with white-lead and castor-oil seeds. The paper used for covering umbrellas is prepared much in the same way, and resists the effects of rain and sun for a long time.

It is, however, to Japan we must look for the most instructive information as to the different uses to which paper may be applied. The Japanese are wonderfully proficient in giving to paper the hardness and weight of heavy wood, and manipulating it in all sorts of shapes. Some of the common paper made is so tough that it can only be torn with difficulty. Coats, hats, shoes, umbrellas, boxes of all kinds, ornaments of every description, pocket-handkerchiefs, fans, &c., are made from paper; in fact a Japanese will turn paper into a hundred useful forms. The imitation-leather paper is made by mixing oil with the pulp; in the same manner all waterproof-paper is manufactured. The juice of persimmons is sometimes also used in making paper intended to resist dampness. From that country we have directions* for making paper-cloth *warranted to wash*, which is known by the name of "Shifu," and which are as follows:—

"Take some of the paper called 'hôshô' (used for letters, books, &c.), or some of the best 'senka' (paper used for making rain-coats), and dye it of the colour required. Boil some of the roots called 'Ron-niaku-no-dama,' with the skins on; try them with the inner portion of a rice-stalk; when it penetrates easily they are sufficiently boiled. Peel them and let the water run off, and then pound them into a paste. Spread this paste on either side of the paper, and let it dry in the sun till quite stiff. Then sprinkle water on it until it is thoroughly damped, and leave it in that state for a night. The next morning roll it upon a bamboo of the thickness of the shaft of an arrow, and force it with the hands from either end into a crumple in the centre; unroll it, and repeat this process two or three times, rolling it from each side and corner of the paper. Then crumple it well in the hands by rubbing it together until it becomes quite soft, and then sprinkle water on it again to damp it. Pull it out straight and smooth, fold it up, and pound it with a wooden mallet. It may then be put into water, as much and as often as is liked, without sustaining injury, having become a strong and lasting material. This cloth is made principally in the Daimiate of Seudai. Boxes, trays, and even saucepans, may be made of this cloth; and saucepans thus manufactured sustain no injury over a strong charcoal heat. Bags may be made of it, in which wine may be put, and heated by insertion in boiling water. Paper thus prepared may be used for papering windows, and will withstand the rain without being oiled."

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* *Vide* "Reports on the Manufacture of Paper in Japan." Printed Parliamentary Paper, No. 400 of 1871.

For the manufacture of oil-paper for rain-coats, &c., the paper should be that locally known as "senka" or "tosa-senka." The glue used for joining the paper is made of young fern shoots, ground and boiled into a paste, and thinned by admixture with the juice expressed from unripe persimmons. The dye is usually green, yellow, red, or black. Whichever colour is used, the colouring matter—generally a powder—is boiled with bean paste, and the paper is then painted with it. The preparation of the paper consists principally in softening it by rubbing it in the hands. The oil used is a seed oil called "Ye-no-abura."

Amongst the specimens of Japanese manufactures at the International Exhibition are the following:—A net coat, worn next to the skin in warm weather by the better classes. This is manufactured by rolling strips of strong paper of equal size into a sort of string, and then working them by hand into a neat net-pattern. It takes some days to complete a garment of this kind, and it will bear washing.

Hats worn by the higher class of Yakunins are made by working paper into a very heavy substance by placing many layers over each other until it attains a very hard and wood-like material. It is then varnished to render it waterproof.

Paper hats are also worked so as to resemble straw hats by the paper being twisted, and then plaited, shaped, and varnished.

Paper made to resemble leather is shown in the shapes of a box and cover for sandals. It is much used by the natives, and is well adapted for binding books, covering boxes, &c.

The above notices will suffice to show the variety of purposes to which paper may be applied besides those which are too well known to all to need any special notice on the present occasion. We shall conclude the present article by a brief allusion to the art of the so-called "water-marking" of paper, which is now carried to a very high state of excellency, so as almost to deserve being classed amongst the fine arts.

The ordinary mode of effecting these paper-marks is that of affixing a stout wire, in the form of any object to be represented, to the surface of the fine wire gauze, of which the hand mould, or machine dandy roller, is constructed. To produce a line water-mark of any autograph or crest, the pattern or device must first be engraved on some yielding surface, from which an electrotype in copper is afterwards taken in the usual manner, thus producing the device in relief. This is then affixed to the surface of the wire gauze of the mould, and produces a corresponding impression on the paper. Supposing perfect identity to be essential, as in the case of a bank note, the device is first engraved on a steel die, those parts which are intended to give greater effect in the paper having to be cut deepest. The die is then hardened and properly prepared in the usual manner, and an impression transferred from it on to a plate of sheet-brass by being placed under a steam hammer or other stamping apparatus. This being done, the die, with the mould plate in it, is next taken to a perforating or cutting machine, where the portion of the mould plate projecting above the face of the die is removed, whilst the portion embedded in the engraved design is left untouched. The latter is subsequently taken from the interstices of the die and placed in a frame upon a backing of fine wire cloth, and so forms a mould for the manufacture of paper of any pattern that may be desired.

Light and shade are occasioned by a very similar process, but one which requires more care, and is consequently somewhat more tedious. In the former case the pulp is distributed equally throughout the entire surface of the wire forming the mould, whereas, to produce the effects of light and shade, means have to be adopted for increasing, to a very great nicety, the thickness or distribution of the pulp, and at the same time to make provision for the water to drain away. This has been accomplished by first taking an electrotype of the raised surface of any model or design; and again, from that, forming in a similar manner a matrix or mould, both of which are subsequently mounted upon lead or gutta-percha, in order that they may withstand the pressure which is required to be put upon them in giving impression to a sheet of very fine copper wire gauze, which, in the form of a mould, and in the hands of the vat-man, suffices ultimately to produce those beautiful transparent effects in paper pulp.

At the Exhibition there is a large display of water-marked papers, consisting principally, so far as England is concerned, of specimens of English and Indian bank-notes; whilst the Imperial State Paper Establishment of St. Petersburg exhibits a large collection, including landscapes, portraits, and other designs. These collections of water-marked papers are exhibited as transparencies, being arranged in glass frames in front of windows, in Room 23, in the south galleries of the Exhibition building.

VII. THE PHYSIOLOGICAL POSITION OF TOBACCO.

By WILLIAM E. A. AXON, M.R.S.L., F.S.S.

Recherches Physiologiques et Cliniques sur la Nicotine et le Tabac. Par le Docteur A. BLATIN. Paris, 1870. 8vo.

Ueber Tabak in toxikologischer Beziehung, mit besonderer Berücksichtigung der im Tabaksrauch enthaltenen chemischen Verbindungen. Vom Dr. HERM. VOHL und Dr. HERM. EULENBERG (Vierteljahrschrift f. ger. Med., N.F., xiv., 2). 8vo.

Académie de Medicine L'Absinthe et le Tabac. Par M. JOLLY. Paris, 1871. 8vo.

Tabak ist Gift! Physischer und psychischer Einfluss des Tabaks auf den menschlichen Organismus. Von B. LUNDAHL. Berlin. 8vo.

Du Tabac. Son influence sur la Santé et sur les facultés intellectuales et morales. Hygiène des Fumeurs par le Docteur DRUHEN ainé. Deuxieme Edition. Besançon, 1867. 8vo.

Die Rauchhexe. Von J. V. STREBEL. Zweite Auflage. Stuttgart, 1869. 8vo.

IS Tobacco good for the health of man? Does it add to his strength, make him readier for work, more capable of endurance, add to his length of life and happiness? The question may for all practical purposes be confined to humanity, for, with one or two exceptions, the brutes avoid the tobacco-plant, and we are not aware that any of them are in the habit of burning its leaves and inhaling the fumes in the manner adopted by man. We may conclude, then, that if tobacco has any uses, to man is due the credit of having discovered them.

In speaking of the physiological position of tobacco, we have to deal with the action of the essential principles of that plant upon the human system. The peculiar effects of tobacco are due to the action of the essential oil of tobacco in the case of chewing and snuffing, and to that combined with the empyreumatic oil in smoking. Nicotine, as this essential principle is called, is so deadly an alkaloid, that the amount of it contained in one cigar, if extracted and administered in a pure state, would suffice to kill two men. According to the experiments of Vohl and Eulenberg, the nicotine is decomposed in the process of smoking into pyridine, picoline, and other poisonous alkaloids, which can also be obtained in varying quantities by the destructive distillation of other vegetable substances.

Nicotine, as for convenience we may continue to call the poisonous principles of tobacco, can enter the body through various channels—by the stomach, by the lungs, by subcutaneous injection, and by the skin itself. But in whatever manner it enters the human system, its effects are, in the main, uniform.

The most immediately noticeable symptom following smoking is the undue acceleration of the labouring forces of the heart. Under the stimulus of tobacco the heart beats more quickly, as is evidenced by the rising pulse. We have not the mass of detailed evidence as to this fact which exists in relation to alcohol, but the experiments made by Dr. Edward Smith, and related to the British Association in 1864, are full of interest. "The experiments were made at 10 p.m., when the rate of pulsation naturally declines (as he had proved by hourly experiments published in his work on the "Cyclical Changes of the Human System"), and at least four hours after any fluid or solid food had been taken. They were made in the sitting posture, after it had been maintained fifteen minutes, and with the most absolute quietude of body and mind; and thus all influences were eliminated but those due to the tobacco. The rate of the pulsation was taken every minute for a period beginning two or three minutes before the smoking began, and continuing during twenty minutes or until the pipe was exhausted.

The following are the chief results obtained :—

Experiment 1.

Pulsation before smoking was 74½ per minute.

Smoking 6 minutes—79, 77, 80, 78, 78, 77 per minute = 78·1 average.

Smoking 7 minutes—83, 87, 88, 94, 98, 102, 102 per minute = 93·4 average.

Smoking 8 minutes—105, 105, 104, 105, 105, 107, 107, 110 per minute = 106 average.

After smoking 11 minutes—112, 108, 107, 101, 101, 100, 100, 100, 100, 98, and 91.

There was thus a maximum increase of 37½ pulsations per minute.

Experiment 2.

(Smoking through camphor julep in a hookah).

Pulsation before smoking, 79½ per minute.

Smoking 6 minutes—81, 81, 81, 83, 82, 82 per minute = 81·6 average.

Smoking 17 minutes—85, 89, 89, 93, 96, 90, 94, 94, 93, 92, 95, 95 95, 96, 94, 97, 93 = 93.

The maximum increase was 17½ pulsations per minute.

Experiment 3.

(Smoking an empty pipe).

Pulsation before smoking, 78 pulsations per minute.

Smoking 11 minutes—76, 78, 77, 76, 79, 79, 80, 80, 79, 78, and 79.

There was no increase in the rate of pulsations from the effort of smoking, or from its interference with the respiration.

Experiment 4.

(To ascertain if, after smoking 6 minutes, during which the effect is very small, and then ceasing smoking, any increase in the effect would follow).

Pulsation before smoking, 75 pulsations per minute.

Smoking 6 minutes—76, 75, 79, 79, 76, 78.
Smoking 1 minute—82. Cease smoking.
Smoking 10 minutes—81, 88, 83, 82, 84, 83, 83, 80, 82.

The rate of pulsations was maintained, but was not materially increased.

Experiment 5.

(To prove if the rapidity of smoking causes a variation in increase of pulsation).

a. Greater volume of smoke.—

Pulsation before smoking, 70½ per minute.

Smoking 6 minutes—68, 70, 71, 70, 72, 74 = 70·8 average.
Smoking 6 minutes—76, 77, 86, 89, 91, 94 = 85·5 average.
Smoking 4 minutes—98, 95, 96, 95 = 96·0 average.

The maximum effect was thus 27½ pulsations per minute.

b. Smoking faster.—

Pulsation of the last minute in the previous part of this experiment, viz. 95 per minute—smoking 3 minutes, 94, 94, 96.

c. The pipe recharged.—

Smoking 5 minutes--87, 93, 96, 96, 96.

There was, therefore, a large effect upon the pulsation, but probably not more than would have occurred with ordinary smoking.

Numerous other experiments were made with tobaccos of different reputed strengths and upon different persons, and the author gave minute directions as to the proper method of making such inquiries."

The heart, then, during the act of smoking, was doing extra work; in some of the experiments this additional labour amounting to more than 50 per cent.

The effect upon the heart is not caused by direct action upon that organ, but by paralysing the minute vessels which form the batteries of the nervous system. Thus paralysed, they can no longer offer effectual resistance, and the heart, freed from their control, increases the rapidity of its strokes, expanding the vessels, with an apparent accession, but real waste, of force.

Its effect in lowering the animal temperature is very striking. When the walls of the blood-vessels are distended with that fluid, the increase in volume decreases the rapidity of the circulation and augments the local warmth. When the walls partially collapse, the circulation becomes quicker, but the heat diminishes. The heat, in fact, is transformed into motion.

Blatin illustrates this by an experiment upon a dog. He took a spaniel of medium size, and noted the arterial tension in the carotid, and the rate of pulsation before and after the subcutaneous injection of 0·004 m.grm. of nicotine into the abdomen. The tension increased from between 0·141 m.grm. and 0·144 m.grm. to between 0·148 m.grm. and 0·155 m.grm.; the pulse rose from 115 to 328 beats per minute.

Again, he introduced the hæmadynamometer into the abdomen of a dog four or five months old, and found the pressure to be 0·082 m.grm. On injecting 0·002 m.grm. of nicotine, the pressure increased to 0·090 m.grm.

The spaniel named as the subject of the first experiment was selected fifteen days after for another operation. Its pulse was at 120. Section of the pneumogastric nerve increased the beats to 210, but the injection of 0·004 m.grm. of nicotine into the abdomen, whilst producing the usual symptoms of poisoning, had no influence upon the circulation. In a terrier dog, poisoned with 0·003 m.grm. of nicotine, the pulse rose from 104 to 190 beats, and the exposure of the pneumogastric nerve to the action of galvanism did not diminish them. Thus the increase of the heart's action, caused by tobacco, results from its paralysing effect upon the pneumogastric nerve. The increase in pressure he considers due, first, to the quickened heart-beat, and secondly, to the paralysing influence of tobacco upon the splanchnic nerve, which is to the vascular system what the par vagum is to the heart. In small doses it increases the excitability of these nerves; in large doses it diminishes it, and that in proportion to their extent. The secondary effect of this is to augment the arterial pressure and heart-beats, and to contract the muscles of the vessels.

The vertigo and trembling noticed in animals poisoned by tobacco are owing to the smaller calibre of the blood-vessels, consequent upon the contraction of their walls produced by nicotine.

Blatin also endeavoured to ascertain the effects of tobacco upon respiration. A small dog, making 16 respirations per minute, was pricked ten times in the abdomen with a needle dipped in an aqueous solution of nicotine; the effect was, in five minutes, to increase the breathings to 38. Three days after, a drop of pure nicotine was introduced into a wound made on the inside of the leg. In an instant the respirations rose from 16 to 25, another moment saw them rise to 38; they then began to decrease, and in five minutes had fallen to 12. Two more drops were now placed on the wound; the breathings descended from 11 to 10, then to 9, stood five minutes at 8, and then another drop of nicotine reduced them to 4. The respiration was now quite irregular. Section of the pneumogastric caused no change, and in a quarter of an hour the animal died. From this it is clear that a small dose of nicotine accelerates, whilst a large one progressively diminishes them. Section of the pneumogastric produces the same effect as a strong dose of nicotine. A small dose accelerates the respiration, even after the section of the par vagum. This will be caused by its action upon the spinal cord. Strong doses cause the same paralysing action we have already noticed acting upon the circulation.

Blatin was struck with the diminution or destruction of the excitability of the nervo-motors when the doses were feeble. Sensibility is only affected by very large doses. When a strong solution of nicotine is injected under the skin of a frog, galvanism has little or no effect upon the nervo-motors. The effect is most noticeable on the nerves nearest the wound.

From this he concludes that the paralysis is caused less by the circulation than by absorption across the tissues. This he tested further, by tying with ligatures one of the posterior members of a frog, leaving only the blood-vessels and nerves free, so that the poison could only reach the nerves by the circulation. Some nicotine was then injected subcutaneously into another member. The poisoned limb did not respond to electrical excitement, but the one which bore the ligatures was evidently sensible to it, though not to the normal degree.

The action of nicotine upon the iris is well known, yet whilst some consider it to produce dilatation, others affirm its effect to be contraction. The iris is composed of two orders of muscular tissue. The circular fibres influenced by the *motor oculi*, and the radiating fibres obeying the great sympathetic, perform the two functions of the iris, dilatation and contraction. The stimulation of the third pair of nerves causes a contraction of the pupil; a larger dose of nicotine destroys its susceptibility and dilatation follows, the upper lid falls, strabismus ensues, the eyeball becomes fixed—in short, the motor power of the eye is paralysed. M. Blatin considers that the muscular fibre of the eye is not at all affected by the poison.

To determine the influence of tobacco upon the secretions, he made some experiments upon a dog, to which small doses of nicotine were daily administered. An increased dryness of the mucous system and a large secretion of urine were the first result. A wound made on its leg had not cicatrised in eight days, in spite of the well-known rapidity with which wounds usually heal in dogs. The mouth became dry, the throat inflamed, the animal, although constantly drinking, was unable to quench its thirst. Some drops of water placed upon the wound moistened it only a few moments. As the pressure of the blood is increased by this poison, in small doses it is a diuretic.

From all these experiments we may conclude that nicotine acts both on the heart and vessels, and is a vasculo-cardiac poison.

Blatin proposes to divide tobacco poisoning into two classes, acute and chronic. The first is the result of a large or unaccustomed dose; the second, the accumulative consequences of doses, perhaps small, but continually repeated. The unpleasant experiences of the first pipe will enable most smokers to understand the nature of this acute poisoning. Children have even been made ill by sucking at pipes, empty, but already coated with tobacco juice. Sometimes a very slight dose exercises a fatal effect upon systems in which tolerance has not been established. Thus a youth of 14, having smoked 15c. worth of tobacco as a remedy for toothache, fell down senseless and died the same evening.* Blatin also tells us of a medical student, aged 22, who, after smoking a single pipe, fell into a frightful state—the heart became nearly motionless, the chest constricted, his breathing was extremely painful, the limbs contracted, the pupils insensible to light, one dilated, the other contracted. These symptoms gradually lessened, but did not disappear until four days after.†

But it is chronic nicotism which has the greatest interest for us. The poisonous effects of tobacco in larger doses are too evident for denial, and need scarcely be insisted upon. Far more important is it to learn whether tobacco, in the quantities daily consumed by its habitual users, has a permanently injurious effect upon the human system.

It is often only after a number of years that nicotic symptoms appear, as though the poison acted by a process of accumulation, until the system was charged to satiety. And thus anything which disturbs the equilibrium of the functions, and so diminishes the elimination of the poison, may give rise to morbid phenomena.

There is a theory not unknown, even amongst medical men, that the toxic influences of tobacco are only transitory, and that all the poison is ultimately expelled from the system. But it is certain, from an experiment of M. Morin,‡ that the nicotine can be detected in the tissues of the lungs and liver after death.

So little is the theory true which would have us believe that the tobacco poison is immediately excreted, that the very cannibals turn up their noses at the nicotised flesh of smokers!§

Blatin made experiments upon three dogs to determine the effects of chronic poisoning. From 15 to 30 c.grms. of tobacco were mixed with their food, and given twice or thrice daily. The vomitings which were noticed at first soon ceased, the action of the heart became extremely irregular, the circulation grew daily feebler, digestion became difficult, appetite diminished, they were subject alternately to diarrhœa and constipation, the mucous membrane of mouth and pharynx soon became so dry that deglutition was very difficult, the gums swelled, the teeth loosened, and some of them fell out. These and other symptoms preceded paralysis of the posterior extremities, blindness, deafness, and death from sheer exhaustion. Their autopsy showed the heart to be pale, soft, slightly atrophied, the blood poor in the red globules, fluid, and deprived of fibrine.

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* DRUHEN, p. 44.

† BLATIN, p. 76.

‡ Year Book of Medicine (New Sydenham Society), 1861, p. 447, and BLATIN, p. 93.

§ STREBEL, p. 30.

A closely parallel case in a human subject is given. Brigitte V., a married woman, of 46 years, having lost one of her children, took to tobacco as a consoler. She snuffed, smoked, and chewed, spending about 2 francs weekly for tobacco. When Dr. Le Briert was called, her voice was rough, not a word could be distinguished, respiration was difficult, pulse feeble and intermittent, the heart beat with difficulty, the pupil dilated and insensible to the light, hearing defective, but not absolutely lost, swallowing difficult, &c., &c. Next day she died, all her organs being in a manner paralysed by the influence of tobacco.

The rough voice of snuff-takers, and the "smoker's sore throat," are also due to the influence of tobacco. Some smokers occasionally spit blood, often immediately after going to bed, and this affection may be confounded with true hæmoptysis.

M. Blatin regards all these local affections as trifling, when compared with the gradual saturation of the system with nicotine, which, accumulating in the tissues, waits for the opportunity, varying, according to individual habits and constitution, of declaring its poisonous nature.

The trembling, which is one of the usual symptoms of acute, is also a common result of chronic, nicotism. A very distinguished Parisian physician had hands which shook so much that he could not write. Whenever he remained without tobacco for any length of time these tremblings disappeared. Another case mentioned by Blatin is noteworthy. A man of 45 years consulted him respecting violent and numerous attacks of vertigo. When he felt one of them approaching he was obliged to lie down wherever he might be in order to avoid falling. In the country, where he had plenty of exercise, they were less frequent than in the town, where his occupation was sedentary. Cessation from tobacco and a tonic regimen quickly restored him.

A physician of 52 was afflicted with similar disagreeable symptoms, and was also cured by abstinence. Habit had become so strong that he could not resist at times the temptation to slight indulgence. Finding that these returns to tobacco were immediately followed by his old painful attacks he renounced it for ever.

The circulatory system presents in chronic nicotism similar symptoms to those found in acute poisoning. The most noticeable of these is the intermittent pulse, of which many cases have been collected by Decaisne and others.

Decaisne speaks of narcotism of the heart, but Blatin does not consider the action to be directly upon that organ, but considers the effects described to result from an irregular relaxation of the ganglia of the great sympathetic nerve.

When a person suffering from intermittent pulse was carefully examined, Blatin found the stoppage in the heart's beat followed a series of apparently normal movements. The systole and diastole succeeded in due regularity, and nothing in the play of the central organ indicated trouble, when the heart suddenly stopped in diastole, sometimes for the space of three arterial pulsations. When it awakens from this syncope its action is abnormally quick, as if it wished to make up for the lost time, and force the mass of blood across the organs at one stroke. But, with force insufficient for this purpose, it is exhausted in fruitless efforts, hesitates, wavers, acquires fresh power, commences again, now violent, now feeble, and fulfils very imperfectly the duties which it should perform. Gradually it calms; a foreign element seems to appease the tumult, the heart again becomes regular. The explanation appears to be that the irritation of the sympathetic nerve stops short the movements of the heart, and thus causes the intermittence; then the susceptibility of the nerve is lessened or paralysed, and the cardiac functions are left to the sole direction of the auto-motor ganglia; hence the disordered beats, which decrease as the nervous force coming afresh from the pneumogastric moderates and regularises it.

From intermittent pulse to angina pectoris the distance is not far. That tobacco may produce all the usual symptoms of that painful disease has been abundantly shown by Beau. To the cases which he has cited may be added an epidemic of this nature noted by M. Gelineau, with which a great part of the crew of the *Embuscade* were struck. The patients were all great smokers. It is worthy of notice that this disease is much more common amongst men than women.

Difficulty of breathing approaching asthma has also been recorded. Blatin gives a case of a young officer whose asthma could be attributed to no other cause, and who was cured by simple abstinence and tonic medicines.*

Tobacco, acting upon the cardiac and pulmonary branches of the pneumogastric, is not likely to leave untouched its gastric terminations. In an animal under the influence of small doses of nicotine the gastric juice is secreted with increased rapidity, and the action of the walls of the stomach is more noticeable. With strong doses or long-continued usage this secretion is very considerably diminished, and the peristaltic motion enfeebled. That is to say, the tobacco acts upon the pneumogastric, excites it in small, and paralyses it in large, doses. The smoker takes his after-dinner pipe or cigar to aid digestion. Undoubtedly, it excites the par vagum, increases the gastric secretion, and accelerates the peristaltic motion. Undoubtedly, also, this daily stimulation enfeebles the nerve, and digestion becomes more difficult. The swing back from the excitement causes a reaction, which only an increase in the doses can overcome. The nerve is partially paralysed. The appetite fails, nutrition is impeded, dyspepsia reigns conqueror.

A military man of 37 years fell into a consumption without any other affection antecedent or concomitant than distaste for food, and salivation. Dr. Roques, after various essays, learned that he was a great user of tobacco, which had led to a sort of chronic fluxion of the salivary glands, and an almost total cessation of the digestive functions, and consequently caused the feeble and consumptive state into which he had fallen. Gradual diminution and ultimate abandonment of tobacco led to a cure in about three months.†

The influence of tobacco upon vision is well known. One of the symptoms produced in acute nicotism is blindness, and chronic nicotism gives rise to similar affections. Thus Mackenzie found that patients afflicted with amaurosis were mostly lovers of tobacco in some form. Sichel found cases of complete amaurosis, which, incurable by other means, were easily conquered by cessation from the weed. Hutchinson found, out of 37 patients, 23 were inveterate smokers. The observations of Wordsworth and others have so clearly established the fact that the continued excitement of the optic nerve by tobacco sometimes produces amaurosis, that it is now generally cited in text-books as one of the causes of that disease.

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* BLATIN, p. 159, from l'Abeille Méd., t. iii., 1846.

† *Ibid.*, p. 165, from Mémoire de Med., et de Chir. Prat., t. v.

We have completed our brief examination of the physiological action of tobacco, but in concluding it may be well to point to some portions of the evidence which are especially noteworthy.

The fact that tobacco reduces the animal temperature is an important one. It shows the fallacy of those who smoke to keep the cold out, and proves conclusively that tobacco is neither a generator nor conserver of vital heat, but, on the contrary, a wasteful destroyer of it.

The influence of tobacco in liberating the heart from those restraints which regulate its healthy action, naturally leads to the conclusion that in frequent doses that organ must, sooner or later, undergo a structural transformation. Although when thus excited it has less pressure to overcome than when in a normal condition, yet the extra exertion cannot but be evil in its results, since it causes an irregularity in the supply of blood, and thus degrades tissue.

Tobacco belongs to the class of narcotic and exciting substances, and has no food value. Stimulation means abstracted, not added, force. It involves the narcotic *paralysis* of a portion of the functions, the activity of which is essential to healthy life.

It will be said that tobacco soothes and cheers the weary toiler, and solaces the over-worked brain. Such may be its momentary effects, but the *sequelæ* cannot be ignored. All such expedients are fallacious. When a certain amount of brain-work or hand-work has been performed, Nature must have space in which to recuperate, and all devices for escaping from this necessity will fail. It is bad policy to set the house on fire to warm our hands by the blaze. Let it, then, be clearly understood that the temporary excitement produced by tobacco is gained by the destruction of vital force, and that it contains absolutely nothing which can be of use to the tissues of the body.

Tobacco adds no potential strength to the human frame. It may spur a weary brain or feeble arm to undue exertion for a short time, but its work is destructive, not constructive. It cannot add one molecule to the plasm out of which our bodies are daily built up. On the contrary, it exerts upon it a most deleterious influence. It does not supply, but diminishes, vital force.

It has been denied that tobacco leads to organic disease, but the evidence is very strong the other way, and it would be very remarkable if continued functional derangement did not ultimately lead to chronic derangement of the organs: that it causes functional disturbance no one dreams of denying; indeed it has been remarked that no habitual smoker can be truly said to have a day's perfect health.

It is scarcely requisite that we should add that tobacco is in no sense a necessary of life.

Even in our days, notwithstanding the vast consumption of tobacco, it is a habit of the minority only. The female sex, to their honour be it said, with very rare exceptions, abstain from this indulgence. If the claims of the apologists of tobacco are correct, why is it that an entire sex avoids it? The frailer body and more mobile mind of woman seem to stand in greater need of "soothing" and "refreshing" than the coarser frame of man.

It is not necessary; for all men do not smoke, and the abstainers are not subject to any inconvenience or disadvantage, but the reverse.

Homer sang his deathless song, Raphael painted his glorious Madonnas, Luther preached, Guttenberg printed, Columbus discovered a New World before tobacco was heard of. No rations of tobacco were served out to the heroes of Thermopylæ, no cigar strung up the nerves of Socrates. Empires rose and fell, men lived and loved and died during long ages, without tobacco. History was for the most part written before its appearance. "It is the solace, the aider, the familiar spirit of the thinker," cries the apologist; yet Plato the Divine thought without its aid. Augustine described the glories of God's city, Dante sang his majestic melancholy song, Savonarola reasoned and died, Alfred ruled well and wisely, without it. Tyrtæus sang his patriotic song, Roger Bacon dived deep into Nature's secrets, the wise Stagirite sounded the depths of human wisdom, equally unaided by it. Harmodius and Aristogeiton twined the myrtle round their swords, and slew the tyrant of their fatherland, without its inspiration. In a word, kings ruled, poets sung, artists painted, patriots bled, martyrs suffered, thinkers reasoned, before it was known or dreamed of. Who of us can realise Moses with a "churchwarden" in his mouth, or St. Paul smoking a prime Havannah?

Think of ancient Greece, of her glory in arts and arms and song, of her poets, sculptors, architects, after whom the moderns toil in vain. We do but follow in their tracks with halting steps and slow, and yet they lived their lives, and thought their deathless thoughts, and gave immortal beauty to the silent stone, without tobacco.

What shall we say, then, to this habit? It is in no case necessary or beneficial; it is a social nuisance; it is devoid of all æsthetic beauty; it is an unmanly leaning on a solace to care and labour neither sought nor needed by the weaker sex; it is an enormous and yearly increasing source of national improvidence. Above all, it is the foe to youthful development, the bane of youthful blood and brain. The subject may seem to some too trivial for serious attention; but when we consider the extent of juvenile smoking, we see that the national life and stamina are seriously threatened by this ignoble habit. So a noble tree, heaven-aspiring, with wide-spreading branches, whose leaves are a refuge for the singers of God, may be attacked by some insignificant parasitical plant, which winds round and round it in serpent-folds, and sucks away its sap and vigour, till the green leaves are blasted and the singers flee away, till the glory is departed, and Death and Ruin alone remain.

NOTICES OF BOOKS.

The Beginnings of Life; being some Account of the Nature, Modes of Origin, and Transformations of Lower Organisms. By H. Charlton Bastian, M.A., M.D., F.R.S., Fellow of the Royal College of Physicians, Professor of Pathological Anatomy in University College, London, Physician to University College Hospital, Assistant-Physician to the National Hospital for the Paralysed and Epileptic. In Two Vols. London: Macmillan and Co. 1872.

Questions concerning the nature and origin of life have for many years exercised the highest powers of the greatest minds. It has always been admitted that at a certain point of the investigation our ability of realising the great mystery of vitality ceases, and we are constrained to admit that—

> "*All that we know is—nothing can be known.*"

To attempt to bridge over the gap which divides the living from the dead by patient and profound research is very laudable and honourable. Experimental evidence has, in late years, made an appreciable advance in this direction; but yet the gap is very wide, and there is much danger that a too hasty generalisation from as yet imperfect data may do harm, even to those who have made the subject their special study—much more to those who belong to the large class of scientific *dilettanti*. The author has presented us with a work of laborious reasoning, and records of many instructive and valuable experiments. He tells us that rather more than three years ago he was content—

> "Stare super vias antiquas;"

but his microscopic investigations led him to renounce many of his old prepossessions for a new doctrine, which now he advocates with the ardour of a convert.

Of the subject opened out, it is obvious that a small portion only can be adequately discussed. The doctrine which the author especially urges is the possibility of the origination of living beings from the elements of dead organic matter. Until the present time this view has been denominated the Theory of Heterogenesis, or Spontaneous Generation. The latter term, however, certainly seems inapplicable when the idea of volition is excluded. Dr. Bastian has therefore employed the less objectionable coinage *Archebiosis*, which indicates the process of passage of the non-living into the living, owing to the occurrence of certain new molecular combinations.

The author commences with a Prolegomenon concerning the nature of vitality, designed to show that philosophically there can be no abrupt line of demarcation between dead matter and living matter. Nevertheless, in our opinion, even with all the light which the doctrines of the correlations of forces and the inter-relations of force and matter give us, we are constrained to admit a vast difference in kind, if not in degree, between the force-attributes of a particle of matter living and those of a particle of matter dead. We may show that the modes of manifestation of force by a living being are purely physical, but that is not sufficient to demonstrate that the force which controls or liberates, changes or co-ordinates these is physical also. And even if we are to renounce the idea of a special vital force directing the living machine, the difficulties are scarcely less, for the relations of force to matter, in reference to degree alone, would, in the case of a living organism, be entirely inexplicable. We must imagine matter supersaturated, as it were, with force, without there being any appreciable affection of its surroundings, and the resultant combination over-riding the laws which govern both force and matter under ordinary conditions. We cannot see that the author's metaphysical speculations at all smooth the path for the easy run of his theory, and we rejoice to find that he admits that of an absolute commencement of life we know nothing whatever. "The gradual transition from the not-living to the living is still hidden from our view, and so, perhaps, it may ever remain."—(P. 128.)

Let us consider the present position of the question that the author discusses. Our common experience of visible Nature teaches us that living things originate from pre-existing living things, and in no other way whatever. The modes of derivation of progeny from parent are sometimes complex and elaborate, at others direct, simple, and demonstrable. The progress of research has tended to show that—even in parasites of parasites of animals, the lesser fleas that bite the greater fleas—the parentage can be traced and demonstrated. And when the highest powers of the microscope are brought to bear upon the subject, the same law is found to hold good. The lowliest visible speck, a mere assemblage of apparently structureless material, can be seen to become detached from the parental mass, and in its turn to propagate other individual buds of protoplasm in like manner. The law, therefore, "Omne vivum e vivo," is universal, in so far as the direct interrogation of visible Nature declares. If there is an exception to this law, in cases of any organisms, it is for those who assert such exception to demonstrate it by evidence. This is what Dr. Bastian attempts to do.

The logical methods which might be adopted for such demonstration are the following:—First, the synthetic method. The fundamental ingredients of organisable matter are carbon, oxygen, hydrogen, and nitrogen, with frequently traces of sulphur and phosphorus. If by taking these inorganic materials, and placing them in juxtaposition, it could be shown that a material possessing the attributes of vitality resulted, the proof would be complete; but this has never been done. The analytical method is equally powerless for the elucidation of the problem, for, as we have just said, in Dr. Bastian's own words, the passage of dead molecules into living matter can never be demonstrated. The method therefore adopted is that of concomitant variations, and here it must be recollected that the several conclusions present, at the best, *alternatives* only.

Direct microscopical examination of a liquid in which the lowest forms of life are prone to develope is considered to afford many data for the elucidation of the problem, though it is admitted that the experience is not crucial. Dr. Bastian says, "When a fluid containing an organic substance in solution is allowed to remain in contact with air, during moderately warm weather, it soon undergoes changes of a putrefactive or fermentative character." It must be admitted, however, that this statement is too general. *All* solutions of organic matter are not susceptible of these changes. In those in which they do occur it is acknowledged that an invariable accompaniment of the changes is the appearance of specks of material, which in the course of a few hours are evidenced as minute, rapidly-moving bodies, known, for the most part, as *Bacteria*. It is urged that, as these have no demonstrable origin from visible parents in the fluid, they must, in all probability, have been formed out of the non-living ingredients. The current views as to the nature of these lowly organisms are very conflicting, and it must be admitted that their life-history has yet to be written. It would appear, however, from morphological considerations, that they are not the simplest form which living matter assumes. The simplest organism with which we are acquainted is the Protamœba: this consists of a mere mass of plasma, apparently perfectly homogeneous and structureless, which multiplies by the mere separation of a portion of its substance from the parent mass: it is simply growing, moving, multiplying protoplasm. In a slightly higher form of Amœba the constituent protoplasm, instead of being perfectly homogeneous, is condensed in granular masses at various points, which become discharged from the parent as germs or ovules. It would seem that a bacterium presents still a higher differentiation: it is of a more definite, cylindrical shape; it moves with great rapidity in certain directions, forward or backward, and multiplies in some cases by fission, in others, as figured by Dr. Beale, who has examined these organisms with the highest powers yet employed—by ovulation. According to the view of the gradual evolution of the living from the dead, it would seem, *prima facie*, most probable that the simplest form—like the protamœba—should be first formed, and the bacterium differentiated therefrom. No observer, however, has substantiated this view.

In the description of the first appearance of living specks in an organic infusion Dr. Bastian's observations closely follow those of Mantegazza. He insists, with a great probability, that if these were derived from germs pre-existing in the fluid, such germs must have been invisible under a power magnifying 1000 diameters. The dilemma, as regards the origin of bacteria, therefore remains—"Either they have been developed from a multitude of pretty evenly disseminated *invisible* germs, or they have been produced in the fluid by a process of Archebiosis."—(P. 297). Considering the extreme minuteness of bacteria themselves, it is surely not contrary to reason to suppose that their germs are so minute as to be diffused through a fluid without betraying their presence to the vision. Is it not as probable that they should be undetected, just as the particles of a salt in solution are undetectable by the microscope? But Dr. Bastian asks—What is the medium whereby such possible germs could possibly be transmitted? He does not discern, with Shelley, that—

> "Those viewless beings,
> Whose mansion is the smallest particle
> Of the impassive atmosphere,
> Live like man."

It is clear that the germs of fungi, as well as other vegetable seeds, are transmitted by the air. As regards bacteria, however, it has been clearly proved, by Prof. Burdon Sanderson, that the great vehicle for their diffusion is *water*—that even ordinary distilled water may contain their germs "in such profusion that even so small a quantity as is introduced into a glass in rinsing is sufficient to render a relatively enormous volume of liquid fruitful."—(Thirteenth Report of Medical Officer of Privy Council.) Dr. Sanderson recognises the particles of the germinal substance of bacteria as of such minuteness as to be not only invisible under the microscope, but insufficient to affect, so far as it was possible to ascertain, the optical purity of the water through which the electric beam was passed. We therefore do not recognise Dr. Bastian's objections as fatal to the view that the lowest organisms observed in a putrefying infusion can be derived from pre-existing living particles. Such particles may exist undetected, and may be transmitted by air, by water, or by both.

The next argument, one that has always played a very important part in the controversy, is that derived from the action of heat, which, it is urged, if of sufficient intensity, must destroy the life of any possibly pre-existent protoplasm in any given medium. Dr. Bastian has subjected organic infusions and saline solutions, in flasks from which air has been expelled, to temperatures varying from that of boiling water in the first series of experiments to upwards of 307° F. in other series. After the flasks had been put aside for certain periods the contents were microscopically examined, with the result of the discovery, in many cases, of various fungoid organisms and bacteria particles. In considering these results, we must at first not fail to make due allowance for the very difficult nature of the experiments, and the liability to error in the conduct of them. All experimenters have not attained the same success in the discovery of organisms, after like experimentation, as Dr. Bastian. Dr. Burdon Sanderson in no case obtained evidence of organisms in fluids heated from the ordinary temperature of boiling water, prolonged for an hour or two in some cases to 200° C. in others. He is very careful, however, to avoid generalisation, and to say that these results only occurred (but this uniformly) in the particular putrescible solutions he employed : these fluids, however, included serum of blood and Pasteur's solution. Prof. Frankland also repeated Dr. Bastian's experiments, with the result of obtaining "not the slightest evidence of life." This is sufficient, we think, to show that so difficult a mode of experimentation is not free from sources of error. But fully admitting that Dr. Bastian met with various fungoid organisms and bacteria, which he has carefully figured, let us consider the possible signification of these results, setting aside, for the moment, the hypothesis of Archebiosis. In the first place, it is necessary to make a division between those fungoid bodies, which it would be impossible to assert to be actually living at the time of examination, and the bacteria, &c., which positively manifested vital movements. It is well known that fungi will occur in saline solutions if they contain nitrogen; and it has been shown that they will freely develope in salts, which might, *prima facie*, appear to afford very unlikely pabula. Unless, therefore, every drop of the solutions employed by Dr. Bastian had, before experimentation, been microscopically searched—a course obviously impossible—the objection must be held valid that the fungi which he took out of his solutions might be precisely those which he placed into them originally. This, however, would not obtain in the case of the actively moving bacteria which were met with in a few instances. It is urged that direct observation has shown that a temperature far short of that of boiling water, 127·5° F., is sufficient to destroy the life of all bacteria. *A fortiori*, therefore, in case of the higher temperatures, life must have been impossible. Without entering upon the much-debated question of the limits of vital resistance to heat, we may yet pause to enquire whether it can be proved, with complete satisfaction, that every single bacterium-particle in a solution, or in a glass vessel in which a solution is contained, is of necessity elevated to the temperature indicated by the external means of heating? It is an old conjuring trick to plunge the hand, previously moistened with a solution of soap, into molten lead, and even iron, and to withdraw it completely unharmed. May we not conceive bacterium-particles in a fluid to be in some cases protected, in like manner, by a film? It must be recollected that if a single particle escape the destructive influence, it is capable of begetting myriads in the solution. Davaine calculated that one bacterium-particle would, in the course of 62 hours, become the parent of

71,000,000,000,000 similar particles. Moreover, Dr. Sanderson has shown, with great probability, that the germinal matter of bacteria may be imported simply by contact of a glass surface which has not been superheated. We cannot but conclude that the investigation on this particular point is so beset with difficulties and sources of error that careful repetition and reconsideration of the experiments are necessary. And then remains the dilemma—either the doctrine of Archebiosis is true, or else living matter is occasionally more able to resist destructive influences than we should, from our own experience, think probable.

A comparatively small portion of Dr. Bastian's book is devoted to the consideration of the phenomena of fermentation. There is, however, a very vehement opposition to the views of Pasteur. The changes which the author characterises as fermentations would, in very many instances, be excluded from such a definition by workers in this field of enquiry. Is it admitted that the change of cyanogen into oxamide by hydrochloric acid, and the decomposition of tartaric acid by heat into carbonic acid, water, and pyrogallic acid, come under the category of fermentations? We believe it wrong to ascribe to Liebig the exclusive view that dead organic matter is the determining cause of fermentations—of course understanding the so-called catalytic changes. Certainly, in case of alcoholic fermentation, Liebig recognises the determinative agency of the living yeast-plant. The latest exponent of this physical theory, M. Fremy, has been constrained to adopt a hypothesis which gives a sort of half-life to the determining agencies of fermentations. M. Fremy classes the organic materials which induce them as "hémi-organisés." We rather think, however, that a perusal of the recent "Comptes Rendus" will tend to the conclusion that the triumph of the controversy remains with M. Pasteur.

Taking all the evidence adduced by the author, we cannot accept the dogma of the origination of living beings from dead organic matter as proved. Still more cogent reasons must be advanced before we can conclude that the same lower organisms which we see multiplying, by conversion of surrounding materials into their own substance, and transmission out of their own protoplasm of a countless progeny, are also formed out of lifeless matter. We cannot yet discard the axiom "Nihil frustra."

The greater part of the second volume of Dr. Bastian's work is devoted to another phase of the enquiry, and the observations contain many points of interest and value to naturalists. The author, having satisfied himself of the truth of Archebiosis, proceeds to consider the process of Heterogenesis. This has usually been confounded with the former hypothesis, but the author defines it as the process whereby "the matter of already existing living things gives birth to other living units wholly different from themselves, and having no tendency to assume or revert to the parental type." Dr. Bastian has supplemented the observations of Pouchet and others, which were said to demonstrate the differentiation of the pellicle formed by the coherence of bacteria, at the surface of a decomposing infusion, into monads, paramecia, &c., by new investigations, tending to show that areas of the same pellicle become converted into spores of fungi. It is impossible to prove whether there is this conglomeration and conversion of bacteria, or whether the appearances are due to developing ova or fungi seen below the film of bacteria. In these observations the hypotheses of Archebiosis and Heterogenesis seem inseparably connected; but not so in the next and extremely interesting enquiry that Dr. Bastian takes up. The mutability of living forms is acknowledged by all observers, the divergence in their views being only a question of degree. Those who legitimately doubt that a milk-globule can become actually transformed into a penicillium (see p. 311, vol. ii., *et seq.*) will find much less difficulty in believing that living matter, under various conditions, is able, Proteus-like, to assume an endless diversity of forms. The morphological views developed by Dr. Bastian are worthy of very attentive study. The work concludes with five appendices, containing details of experiments and an enquiry concerning "The Germ Theory in relation to Epidemic and 'Specific' Contagious Diseases."

Although we have had occasion to differ from many of the author's conclusions, we are glad to acknowledge that Dr. Bastian has made an important contribution to scientific literature, evidencing wide research and laborious reasoning, and has spared no pains to illustrate his meaning by well-executed wood-engravings.

Air and Rain. The Beginnings of a Chemical Climatology. By ROBERT ANGUS SMITH, Ph.D., F.R.S., F.C.S., (General) Inspector of Alkali Works for the Government. London: Longmans, Green, and Co. 1872.

"WHEN we are children, air is to us nothing." With this pithy little sentence Dr. Smith commences his exhaustive treatise upon the constituents of the atmosphere and the results of his investigation; and while he shows how especially erroneous is the idea of the nothingness of air we entertain as children (and not unfrequently by our actions as children of a larger growth do we give credit to this idea), he tells us how far we may be alarmed, in invading with microscope and chemical test the regions around us, by the army of aërial corpuscles and microcosmic organic matter which our fears may endow with undue power. "We have," he says, "many people so afraid of this organic matter of the air, and of all its floating particles, that they would like to filter it all out, and breathe the gases pure. We must not allow our fear to go too far. We have no reason to be sure that air free from floating particles would be wholesome; we have only the proof that, if there is an excess of some kind, it is unwholesome. Apparently everyone can breathe air tainted with any disease without being hurt, if the taint is small enough. Inconceivably small particles injure; but we must learn to divide even the inconceivably small. We can bear a larger amount of taint if it is diluted enough. Dilute sufficiently the air of a hospital, and infection ceases. One short time of the infected air produces disease; a long period of the diluted air produces none, although the number of particles that must pass over a certain spot must be much greater in the long time than when the stronger mixture passes in the short time. We learn from this that the amount that does injury is not infinitesimal; there must be a certain quantity. I do not doubt that we shall measure that readily: we can readily measure the amount of ammonia and organic matter in the infectious and non-infectious atmospheres. The really practical work must begin after this. It was my desire to have done so in one of the hospitals, but having begun I was interrupted, and it must not be done in a hurry. I do not feel hopeless of being able to say that in a scarlet-fever atmosphere there must not only be so much nitrogenous organic matter and so many germs, otherwise infection will be certain."

For the actual chemical instruction relative to the matter before us we must refer the reader to the work itself; but to the general subject of ventilation we may here give some attention.

"The demands of ventilation would be best explained," says Dr. Smith, "if we could reply to these questions:—What is the smallest amount of carbonic acid which may be called injurious? and what is the smallest amount of organic matter?" The answer to the former question Dr. Smith has determined very accurately by means of a hermetically-sealed leaden chamber, and the effects on his own person of remaining in different states of the atmosphere. The amount for a healthy place is below 0·4 per cent, while about five times that amount affects a candle sensibly. But the practical question—How often must we renew the air of a room in order to maintain a given degree of purity?—is that most nearly affecting the general reader, and which we shall endeavour to answer from the work before us. Suppose that a man brings 100 cubic feet of air to contain 0·4 per cent of carbonic acid in an hour from zero, he will bring 1000 cubic feet to contain 0·04 in the same time, being at the end of the hour ready for another 1000 cubic feet, in order not to exceed this limit. But in actuality the air supplied also contains 0·04 per cent of carbonic acid, and the space in which the man is situate cannot be maintained at the degree of purity. The limit usually assigned is 0·06: this being 0·02 higher than that which he receives as fresh, a man would require a constant supply of 2000 feet per hour. But then the air-supply of the majority is not so nearly pure as represented by 0·04, and it may be necessary to increase the supply to 3000 cubic feet per hour. Now that we know the quantity to be supplied per hour, we must ascertain the rate of change at which the air-supply becomes dangerous as a draught: this has been put down at a velocity less than 5 feet per second, with an entry of 48 square inches and a similar outlet, independently of the fire-place in the room; or, in other terms, the 3000 cubic feet of air per head must be delivered so that the whole air in the space inhabited is changed not oftener than six times an hour. It is so difficult, or indeed impossible, to effect so many changes per hour that separate ventilation must be provided. Of the nature of this ventilation it is difficult to form an opinion, since it varies with every case. Thus we see that in the case of a small room, with a large number of inhabitants, the supply of air to prevent accumulation of carbonic acid must amount to a draught that is in itself dangerous, and that consequently the larger the number of persons the narrower are the limits between the two dangers. But a third element comes now to light, for with increase of numbers there is an increase of heat, and a percentage of carbonic acid that could be easily withstood under the influence of cold becomes exceedingly injurious at a high temperature. These reasons against overcrowding are plain to any average intelligence; and in Dr. Smith's work so full are the illustrations that he must be dull indeed who is not incited to a regard for healthful ventilation. Most cordially do we recommend Dr. Smith's book to our readers, and we think it would in many cases be an admirable present to those who could, if they knew how, render help to their fellow-creatures by supplying information as to the extremes of draught and slow-poisoning by bad air.

Essays on Astronomy: A Series of Papers on Planets and Meteors, the Sun and Sun-surrounding Space, Stars and Star-Cloudlets; and a Dissertation on the Approaching Transits of Venus. Preceded by a Sketch of the Life and Work of Sir John Herschel. By RICHARD A. PROCTOR, B.A. Camb., Honorary Secretary of the Royal Astronomical Society; Author of "Other Worlds than Ours," &c. London: Longmans and Co. 1872.

THESE are the collected essays, by Mr. Proctor, referred to in his other works, particularly in "The Sun" and "Other Worlds than Ours," and arranged in one volume, for the convenience of readers who have no means of reference to essays published in the "Proceedings" of scientific societies. The first three essays relate to the life and work of Sir John Herschel; the remaining papers are devoted to dissertations on the planets Mars and Saturn, meteoric astronomy, the zodiacal light and the solar corona, star and star-cloudlets—their nature, movements, arrangement in space, and aggregation into systems. Further, there are ample appendices on the rotation of Mars and the proper motion of the Sun, as well as three essays on the transit of Venus. This breathless list conveys but an inadequate idea of the labour which Mr. Proctor continually undertakes for the benefit of the public; and, what is more, the popular descriptions are given *after* the facts have been presented to and received by some eminent Society. Thus Mr. Proctor has a twofold claim upon the public, for hard work and for accuracy. We can recommend this volume as being one of the most solid Mr. Proctor has yet written.

An Exposition of Fallacies in the Hypothesis of Mr. Darwin. By C. R. BREE, M.D., F.Z.S., Senior Physician to the Exeter and Colchester Hospital; Author of "Species not Transmutable, nor the Result of Natural Selection," &c. London: Longmans and Co. 1872.

WE cannot here enter into the discussion invited by Dr. Bree, because we should be led beyond the limits of our space; but we can recommend the work as a clear and earnest protest against the exaggerated claims of the Darwinian theorists. But the work remains, for all the care bestowed upon it by its author, still only a protest. Dr. Bree has attempted too much. Had he devoted his energies to single combat with Dr. Darwin some sore wounds might have resulted to the latter, but when he encounters, also, Mr. Spencer and Professor Huxley, he should not expect to make much mark against such redoubtable champions. There are, in Dr. Bree's present work, many valuable arguments against the Darwinian theory, which arguments may be considered to fail solely for lack of illustration. In saying so much we have almost taken the field against Dr. Bree; this we do for the reason that we think his high talent as an entomologist and ornithologist would be serviceably employed if concentrated to the answering of one point of the theory of evolution, for in the sciences named Dr. Bree has corrected not a few errors made by Dr. Darwin. Thus his work is calculated to lead to the ultimate discovery of the truth; and we recommend to all our readers, who like to know something of both sides of a question, the perusal of Dr. Bree's exposition.

Magnetism and Deviation of the Compass. For the Use of Students in Navigation and Science Schools. By JOHN MERRIFIELD, LL.D., F.R.A.S., Head Master of the Plymouth Navigation School. London: Longmans and Co. 1872.

THIS is a work well adapted to the candidate in navigation. The explanations are clear and well arranged, embracing every useful information on magnetism and the deviation of the compass. The want at present felt by students, on account of the alteration in the examinations conducted by the Board of Trade, is well supplied in this manual, which will prove of great benefit to those preparing for a nautical life.

As Regards Protoplasm. By JAMES HUTCHINSON STIRLING, F.R.C.S., and LL.D., Edin. New and Improved Edition. London: Longmans and Co. 1872.

IN the present edition of Dr. Stirling's controversial pamphlet there is appended a second part, in reference to Prof. Huxley's second issue, and a preface in reply to Prof. Huxley's "Yeast." The subject-matter is too well known to the public to need again noticing in this place: we may say that the additions are too personal to be either quoted or condensed with advantage. The pamphlet should be read in its present form.

Patterns for Turning: Comprising Elliptical and other Figures Cut on the Lathe without the Use of any Ornamental Chuck. By H. W. ELPHINSTONE. With Seventy Illustrations. London: John Murray. 1872.

MR. ELPHINSTONE, in this elaborately illustrated work, provides directions for the cutting of elliptical and other figures, on a lathe furnished with a division-plate, an ornamental slide-rest, and eccentric cutting-frame, and an overhead motion. The book is intended for perusal on the bench, and is admirably arranged for the use of the practical mechanic. The formulæ are exceedingly simple, and require but a very elementary knowledge of mathematics. Every amateur turner should obtain a copy of Mr. Elphinstone's work.

A Handbook of Chemical Technology. By RUDOLPH WAGNER, Ph.D., Professor of Chemical Technology at the University of Wurtzburg. Translated and Edited from the Eighth German Edition, with Extensive Additions, by WILLIAM CROOKES, F.R.S. With 336 Illustrations. London: J. and A. Churchill. 1872.

WE present to our readers a notice of this work, although criticism is of course not within our province. We give a synopsis of the contents, in the hope that our readers will find a practical answer to many technical questions of daily occurrence. Under the head of Metallurgical Chemistry the latest methods of preparing iron, cobalt, nickel, copper, copper salts, lead and tin and their salts, bismuth, zinc, zinc salts, cadmium, antimony, arsenic, mercury, platinum, silver, gold, manganates, aluminum, and magnesium are described. The various applications of the voltaic current to Electro-Metallurgy follow under this division. The preparation of potash- and soda-salts, the manufacture of sulphuric acid, and the recovery of sulphur from soda-waste, of course occupy prominent places in the consideration of chemical manufactures. Soap manufacture will be found to include much detail. The technology of glass, stone-ware, limes, and mortars, will be interesting to the builder and engineer. The technology of vegetable fibres has been considered to include the preparation of flax, hemp, cotton, as well as paper-making; while the application of vegetable products will be found to include sugar-boiling, wine and beer brewing, the distillation of spirits, the baking of bread, the preparation of vinegar, the preservation of wood, &c. Information is given in reference to the production of potash from sugar residues, the use of baryta salts, the preparation of sugar from beet-root, tanning, the preservation of meat, milk, &c. The preparation of phosphorus and animal charcoal are included in the technology of animal products. The preparation of the materials for dyeing have required much space. The final sections of the book are devoted to the technology of heating and illumination, the production of gas, coke, and tar from coals; the extraction from the tar of benzol, carbolic acid, aniline, anthracen, asphalte, naphthaline; the preparation of tar colours, as rosaniline, aniline blue, Manchester yellow, Magdala red, alizarine, iodine green, picric acid, &c.

The work is illustrated with 336 engravings. In presenting it to our readers we offer the latest improvements in chemistry, as applied to arts and industry, with the endeavour to merit the confidence of the manufacturer and the student.

Health and Comfort in House Building. By J. DRYSDALE, M.D., and J. W. HAYWARD, M.D. London and New York: E. and F. N. Spon. 1872.

IN this work we have most valuable practical suggestions as to the construction of houses with regard to warmth, comfort, and ventilation. Drs. Drysdale and Hayward, after devoting much time and thought to the subject, recommend that—in order to obviate any ill effects resulting from the free ingress of cold air into our rooms—a system of warming and ventilation be employed, utilising the heat of the kitchen chimney by means of a syphon-shaft and foul-air chamber. The latter consists of an air-tight zinc drum, about 6 feet in diameter by 5 feet high, placed under the roof of the house, each room having a separate escape-tube to the drum. The expansion of the water is provided for by a safety tube at the top of the circuit. This is the high-pressure system. The low-pressure system consists of a boiler, with pipes from 1 to 4 inches diameter, and a supply-cistern; coils of tubing, about 2 inches diameter, are placed where warmth is required, smaller pipes being used to convey the water to the coils. The size and length of the apparatus cause it to be rather unsightly, and the heat cannot be so equally distributed, although it is preferable in places removed from large towns, from the fact that an ordinary mechanic can attend to any repairs that may be necessary. The high-pressure system is better adapted to large houses, where several lobbies require warming. That described in the foregoing work is an admirable system, peculiarly adaptable to our climate, where the direct admission of cold air to our rooms is endurable only a few months in the year with due regard to health; and we commend the work to our readers as well deserving their consideration.

New Formulas for the Loads and Deflections of Solid Beams and Girders. By WILLIAM DONALDSON, M.A., A.I.C.E.; Author of "Switches and Crossings," and a "Treatise on Oblique Arches." London and New York: E. and F. N. Spon. 1872.

IT has been well said, by an American writer, that "The least deviation from the assumed standard (of pronunciation) converts the listener into a critic." And the same may be said of spelling. In the present work we have *formulas*, the assumed standard being *formulæ*. Now Mr. Donaldson may be more studious of the formation of the plural in the English language than is perhaps agreeable; for certainly this deviation from the assumed standard not only causes the thoughtful reader to pause, but its reiteration interferes with the grasping of the sense, and is most damaging to the ready perception of the course of reasoning. Where argument has to be so closely followed as in a mathematical work, every consideration should be given that there occurs nothing to distract the attention. This variation we advise Mr. Donaldson to alter in future editions, at least in the body of his work. We say advisedly in future editions, for the practical worth of the work will be at once recognised by the engineer. The formulæ are clearly deduced and plainly stated, while the illustration of the applications is of a high order.

Contributions to Molecular Physics in the Domain of Radiant Heat. A Series of Memoirs published in the "Philosophical Transactions" and "Philosophical Magazine," with Additions. By JOHN TYNDALL, LL.D., F.R.S., Professor of Natural Philosophy in the Royal Institution. London: Longmans and Co. 1872.

SCIENTIFIC readers will recognise these memoirs which Dr. Tyndall has now produced in a book-form; to the general public the work will not be of interest, being a more technical investigation than those elucidated in Dr. Tyndall's well-known volumes. To recommend the work is unnecessary, but we may say that the additions conduce much to clearness.

On the Mechanism of Accommodation for Near and Distant Vision. By R. E. Dudgeon, M.D.

This is an exhaustive pamphlet on the mechanism of accommodation for near and distant vision, and evidences much careful and experimental research, the more praiseworthy and valuable as it is the endeavour of a professional man, of much daily experience, to throw light upon a difficult subject.

Hypotheses. By F. J. Finois. New York: Voytits, Ann Street. 1872.

Mr. Finois's pamphlet of 33 pages contains as much matter for thought as many volumes. Each hypothesis is included in a short sentence, and deals with a certain phase of the subjects generally classed under the heads of sidereal, sidero-terrestrial, terrestrial, intellectual, mental, and social phenomena. We quote an illustration from the division of intellectual phenomena.

"§ Objects have been accepted as self-existent, whilst space has been declared to be 'naught,' or an abstract notion, which, however, is measured by a yard stick.

"Space is therefore to be accepted as just so self-existent as any object.

"§ The Intellect never has succeeded in analysing an Atom, a Force, and a point of Space, into any other elements.

"Matter, Forces, and Space are therefore to be accepted as the ultimate constituent elements of the Universe, which itself constitutes a sphere with diameters of infinite length.

"Forces occupy Atoms, and atoms occupy points of space. Forces cause the atoms to change their places in space. Their inseparable union and their mutual relation, to be called primordial affinity, manifest themselves as motion, of which synthesis, development, decadence, and analysis of compound forms is the result.

"§ There are three general senses for receiving impressions made by the phenomena:—

"1. The sense of sight pre-eminently for Space.

"2. The sense of touch pre-eminently for Matter.

"3. The sense of hearing pre-eminently for Force.

"The individual senses of smell and taste are auxiliaries of the sense of touch, for Matter.

"The senses assist each other, so that their combined action alone furnishes complete sensations.

"§ There are three general measures:—

"1. Space is measured by the straight line, and its compounds represented by the respective measuring instruments.

"2. Matter is measured by weight.

"3. Force, or its intensity of action, manifesting itself as velocity, is measured by the diurnal rotation of the earth, the day and its divisions, represented by time-pieces.

"§ Every language contains words which designate space, matter, and force.

"The mathematical formulæ of physics, pre-eminently the science of motion, contain the signs of these elements."

The book cannot be merely read; it must be studied line by line, word by word, and is well worthy the trouble.

Treatise on the Manner of Testing Water-Wheels and Machinery. By JAMES EMERSON, of Lowell, Mass. Lowell, Mass.: Stone and Huse. 1872.

WHILE we cannot here enter into a description of the methods of testing water-wheels and machinery employed by Mr. Emerson, his eminence as an American engineer will recommend his work to the notice of all concerned in this branch of engineering construction. The book is fully illustrated with engravings of the various wheels and turbines in use in American streams; and contains tables of quantities of water, in cubic feet per minute, flowing over weirs of different lengths, with varying depths of water, as well as tables of the velocity due to head of water. The work contains much in little space.

Corso di Geologia del Professore Antonio Stoppani. Volume I. Dinamica Terrestre. Milano: G. Bernardoni e G. Brigola. 1871.

THIS course of geological study is virtually an enlarged edition of the "Note ad un Corso di Geologia," published by Professor Stoppani in 1865. The present work will be comprised in three large octavo volumes, of which the first is now offered to the public. The subject of terrestrial dynamics is considered under two heads—the dynamics of the exterior of the earth, atmospheric and oceanic circulation, &c., and the investigation of the action and results of subterranean forces. Under the latter head we have a full but concise account of volcanic eruptions, particularly of the history of Vesuvius. The work is well illustrated, and will form a valuable addition to the library of the geologist, as being a record of geological facts founded upon the authority of Dr. Stoppani.

Life of Richard Trevithick, with an Account of his Inventions. By FRANCIS TREVITHICK, C.E. Illustrated with Engravings on Wood, by W. J. WELCH. Volume I. London: E. and F. N. Spon. 1872.

VERY little has been said or recorded of Trevithick that is now known to the general reader; yet the history of his inventions is almost one with an account of the steam-engine, especially with the earlier forms employed in mining operations. That the present biography is written with a loving hand may at once be gathered; and the book is remarkable from the fact that, though the pen has been taken up by a friend, the faults and peculiar temperament of the subject of the biography are by no means glossed over. The true character of Trevithick is caused to appear through the letters and documents of which the biography, as written by Mr. Francis Trevithick, may be considered the setting. The work might also be called a history of the steam-engine, and in its twofold character will be doubly welcome to the student of this branch of engineering science. The illustrations are capitally arranged, being at the same time ornamental and descriptive. The book will be read with advantage by all, while, as a record of the details of the progress of steam, it will occupy a prominent place in the front ranks of scientific literature.

Modern Examples of Road and Railway Bridges; illustrating the most Recent Practice of Leading Engineers in Europe and America. By WILLIAM H. MAW and JAMES DREDGE. London: Offices of "Engineering," 37, Bedford Street, Strand. Berlin: A. Asher and Co., 11, Unter den Linden. 1872.

WITHOUT in any way desiring to deny the value of sound theoretical knowledge as to the principles of bridge-building, it must be admitted that, in the construction of such works, many circumstances may be expected to arise wholly beyond the reach of any previous calculations. The treatment of such occurrences successfully requires often a master mind, possessed of good practical skill rather than of theoretical refinement; and this can only be obtained by experience, accompanied by a knowledge of what has previously been accomplished. For this reason any publication which deals in a scientific manner with the best known achievements in any branch of modern science cannot fail to prove a valuable contribution to scientific literature. Of such a character is the volume now before us, which contains accounts of upwards of seventy bridges, of a variety of types of construction, selected—as stated by the joint authors in their preface—so as to illustrate the most recent practice of the leading engineers of this country, of the Continent, and of the United States; but while the chief subjects for illustration and description consist of the principal bridges erected during the last ten years, the work includes also accounts of special structures not generally classed under the generic term "Bridge," but which, strictly speaking, belong to it; such as the sewer-crossings and other special structures on the Metropolitan Railway, the arrangements for carrying gas mains in connection with the Beckton Gas Works, railway station roofs, &c.

This book is well got up, and printed upon a rich thick paper, and the subject matter is illustrated with numerous well-executed woodcuts, whilst there is, also, that great desideratum for all works of reference, a good index. The description of each bridge is given in a clear and concise manner, accompanied by such statistics of weights, strains, &c., as are necessary for a complete comprehension of the particulars in each case.

Of course iron bridges and works occupy the greater portion of the book; but there are also given specimens of bridges of timber, masonry, and artificial stone, or the *béton aggloméré* of M. Coignet. Bridges on the truss, girder, cast-iron, and suspension principles are fairly represented, whilst swing-bridges, piers, and methods adopted in the reconstruction of bridges in France, are not omitted.

Whilst this work must be invaluable to professional men, it will prove, we think, by no means uninteresting to the intelligent general reader.

ABSTRACT OF THE PROCEEDINGS OF THE BRITISH ASSOCIATION.

BRIGHTON MEETING.—1872.

Retiring President.—SIR WILLIAM THOMSON, LL.D., F.R.S.
President.—DR. WILLIAM B. CARPENTER, LL.D., F.R.S., F.L.S., F.G.S.

THE present Meeting of the British Association for the Advancement of Science, held at Brighton, has been attended with the greatest success. The arrangements of the Local Committee were admirable, and the many places of interest near to the London of the Sea were freely opened to visitors. It is unnecessary to enter into the detail of these arrangements, which could interest but few, and which will be well known to many: it is our purpose to present the reader with an Abstract of the Papers read before each Section. With this view we present a consideration of the chief arguments advanced in the *Inaugural Address of the President.*

"ON MAN AS THE INTERPRETER OF NATURE."

It is recorded in earliest history, and remarkable at the present day, that man, whilst declaring the faults of his fellows, regards his own with a very partial vision. Of this inherent weakness we have a most flagrant example in the Address of the President of the British Association to the ladies and gentlemen assembled at Brighton to express their interest in the scientific discoveries of the last year. Dr. Carpenter has taken upon himself to lead them "to the consideration of the mental processes by which are formed those fundamental conceptions of matter and force, of cause and effect, of law and order, which furnish the basis of all scientific reasoning, and constitute the *Philosophia prima* of Bacon." Now, by Dr. Carpenter's own showing, this means *his* individual consideration of the mental processes; in fact, a close adherence to the sophistry of judging others by the standard of self; for he afterwards says, "Nature is what he (each man of science) individually believes her to be." Thus, that variation in conception which Dr. Carpenter asks for in every other branch of science, he denies to mental philosophy. It is not enough in his consideration of scientific exactness that the high probability that the spectrum of a hydrogen flame means hydrogen when seen by Mr. Lockyer in the spectrum of the sun's chromosphere, or that Dr. Huggins should deduce from the different relative positions of certain lines in the spectra of different stars, that those stars are moving from or towards us in space—a probability that has been accepted by every scientific man as a certainty, upon the assumption that the same lines represent the same elements in every luminary (we use Dr. Carpenter's own propositions throughout)—but Dr. Carpenter must point out that these conclusions *may* or *may not be* correct. We then have a direct aspersion cast upon all scientific men and all scientific methods. Scientific men are told slightingly what they knew before, viz., that they are as human beings fallible and individually liable to form erroneous conclusions. Every scientific man shows his appreciation of the fallibility of his judgment by carefully guarding against error, and by acknowledging error when it occurs to him. But, on the other hand, a philosopher has hitherto been considered justified when the same event has happened or happens always under the same conditions, in deducing a conclusion which he may submit to his fellow-inquirers to stand or fall as it may be true. Yet this tacit understanding of human fallibility does not satisfy Dr. Carpenter, who requires that we should always qualify our deduction with "*may or may not be.*" Notwithstanding, that in no one of Dr. Carpenter's own works do we find that he adheres to his own formula—and he should remember that even law-makers are held bound to keep the laws they make—we cannot, and we think scientific men generally cannot, but express the opinion that Dr. Carpenter has exceeded all bounds of decorum. He has been guilty of proclaiming either that scientific investigation is conducted loosely, or that scientific men assert that which is not positively true, for in no other light will his address be intelligible. In either case the assertion is erroneous, and calculated to lower other men in popular esteem, and exalt Dr. Carpenter as the discoverer of an imposition. Such conduct is unworthy a man holding the position of President of the British Association.

We will now examine the assumption upon which the whole of Dr. Carpenter's address turns. He says, "I hope to satisfy you that those who set up their own conceptions of the orderly sequence which they discern in the phenomena of nature, as fixed and determinate laws, by which those phenomena not only are within all human experience, but always have been and always must be invariably governed, are really guilty of the intellectual arrogance they condemn in the systems of the ancients, and place themselves in diametrical antagonism to those real philosophers, by whose comprehensive grasp and penetrating insight that order has been so far disclosed." Who do set up their own conceptions as fixed and determinate laws? Certainly not accredited scientific men, and yet upon the assumption that such men, and those who so strongly adhere to their own conceptions are the same, does Dr. Carpenter assail scientific men not only collectively, but individually. Dr. Carpenter's remarks would be calculated to form a serious obstacle to the advancement of science, were it not that, to use his own words, judgment "is eminently a personal act, the value of its results depending in each case upon the qualifications of the individual for arriving at a correct decision."

There is one convincing argument against the liability of error from individual interpretation which Dr. Carpenter has overlooked. It is that philosophic principles are really not isolated, neither are they individual, for if each subject be taken up by one man there remains sufficient diversity to prevent error in considering the conclusions collectively; but it happens that many men with many theories take up the same subject with concordant results. So that unless Dr. Carpenter flies directly in the face of all received reasoning on probability of error, which being of error includes probability of correctness, his remarks are childish.

Dr. Carpenter further places great stress upon the invidious distinction between "seems" and "really is," as regards the scientific interpretation of Nature. Has science been proved sufficiently inaccurate to warrant such a distinction? We think not, and that the distinction has been made by Dr. Carpenter on his own authority alone. Again, he tells us that "the philosopher's interpretation of Nature seems less individual than that of the artist or the poet;" and proceeds to reason upon this ground,—a veritable quicksand, for whereas the artist and poet are allowed liberties on account of the machinery they employ, the philosopher is allowed none, even while his machinery is of a more restricted order. Even generalisation Dr. Carpenter denies to the scientific enquirer, who employs generalisation as the artist does his rules of perspective or the poet the rules of prosody and grammar—that is, as a method of order. But the simile of artistic and poetic interpretation is in itself faulty, for the artist and poet are not required to represent Nature accurately, but only so far approximately as may affect the feelings, whilst the philosopher must most correctly trace Nature as she presents herself, if his interpretation is intended for the eyes of common-sense men or of men co-equal in scientific attainments, according to the speciality of the character of the phenomenon to be interpreted: the one is an appeal to the feelings, the other to the reason. The one calls not for accuracy, the other demands it.

Dr. Carpenter is far from understanding the difference between laws made for men and those made by them: in the first there is not, and has never been, a cessation of the directing force, whilst in the latter the law is not always enforced. In the one case, given the same conditions the same results are inevitable, because the origin is constant; but in the other the results vary with the origin. But this consideration brings us within the territory of Theology, with which, in common with Dr. Carpenter, we, as professed scientific men, publicly have nothing to do; and as we do not recognise Dr. Carpenter in any way as an authority on this new point which he appears anxious to claim, we shall merely endorse the general belief that the boundaries of theology and science are, where they touch, perfectly defined, while we shall certainly resent the endeavour he has made to place theology in supremacy to science in the investigation of the Laws of Nature, whatever we may do in investigation as to the Cause of those laws.

The very attributes of science have been attacked by Dr. Carpenter; and whatever may be the issue of the matter, there remains the fact that he has placed himself under the necessity of more clearly stating his reasons for the attack.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President.—Warren de la Rue, D.C.L., Ph.D., F.R.S., V.-P.R.A.S., V.-P.C.S.

Vice-Presidents.—Prof. G. C. Foster, F.R.S.; F. Fuller; James Glaisher, F.R.S.; J. Norman Lockyer, F.R.S.; J. Phillips, F.R.S.; H. J. S. Smith, F.R.S.; W. Spottiswoode, F.R.S.; Sir W. Thomson, LL.D., F.R.S.; Sir Charles Wheatstone, D.C.L., F.R.S.

Secretaries.—Prof. W. R. Clifford, M.A.; J. W. L. Glaisher, B.A., F.R.A.S.; Prof. A. S. Herschel, B.A., F.R.A.S.; G. F. Rodwell, F.R.A.S., F.C.S.

The President opened the proceedings by stating that he would confine his attention to astronomical photography. He showed that, at the very outset, astronomical differs from ordinary photography, inasmuch as the image of the object which falls upon the collodion film is always in motion. Strata of air are ever in motion between the plate and the object, and each of these strata causing refraction the result is a "flickering" image to be impressed upon the sensitive film, being a similar effect, from the same cause, of the appearance of the "twinkling" of stars. Dr. de la Rue has observed that this flickering, at certain times, chances to be at a minimum, and it has been at such times that he has obtained his celebrated photographs of the moon. He then detailed the difficulties arising from the non-coincidence of the foci of the chemical and visual rays of light, from which it accrues that, if the prepared plate be placed where a visually well-defined object falls upon the film, the focus not being that of the chemical rays the best result is not obtained. Dr. de la Rue, to remedy this defect, employs a reflecting instead of a refracting telescope. Mr. Rutherford, of New York, on the contrary, employs a refracting telescope, but one in which special adjustments have been made. The rays of light from the heavenly bodies are not only refracted during their passage through the atmosphere, but are absorbed by floating particles, solid and liquid, this absorption amounting to, perhaps, two-thirds of the chemical rays. For these and similar reasons, it would appear advantageous that the British Association or the Royal Society should possess a permanent observatory, situated at a great elevation, in a climate as free as possible from cloud. The President of the Section detailed the successful experiments of Lord Lindsay and Mr. Rannyard, as to the question whether reflections from the back surface of the photographic plate played any part in the production of the fringes observed in some astronomical photographs. In these experiments plates of ebonite and non-actinic yellow glass were prepared, and it was soon found that the outer haze completely disappeared in the photographs taken on ebonite, while on the yellow glass plates it was much fainter than on ordinary white glass plates. A wetted black paper at the back of an unground plate greatly diminished the outer haze; and a yellow glass plate ground on both sides, the back coated with a black varnish, caused the outer haze to entirely disappear, showing the greatest part of photographic irradiation to be due to reflection from the second surface.

The failure of photography to present truthful pictures of nebulæ and comets was passed under consideration, and thought to be due to the variation in atmospheric currents and the interposition of aqueous and solid particles. In following up the consideration Prof. Zollner's theory of the self-luminosity and train of comets was commented upon, the President inclining to the view that electricity may be demonstrated to be sufficient cause, provided it be granted that electricity may be developed by the action of solar heat,—if not in the process of evaporation, at least in the mechanical and molecular disturbances resulting from it. In conclusion, Dr. de la Rue expressed a hope of seeing the photographic method, as applied to sun-observations, joined to the work of Greenwich Observatory, and alluded to the importance of the subject now before the Royal Commission, presided over by the Duke of Devonshire.

Colonel Strange proposed the vote of thanks to the President, and the proposition was seconded by Sir William Thomson.

The Eclipse Committee.—The Report of this Committee, by Mr. J. Norman Lockyer and Dr. J. Thomson, was read by the Secretary, and detailed the results of the Melbourne and Indian Expeditions. The Indian Expedition made known to us that the luminous hydrogen exists at the enormous distance of seven or eight minutes from the sun's limb, instead of only about ten seconds, as previously calculated; and that there was strong radial polarisation of the corona.

Luminous Meteors.—The Report of the Committee, read by Mr. James Glaisher, F.R.S., included the notice of the August and November meteors. The work done in determining the radiant points of the meteors occupied much of the Report. Mr. Birt, F.R.A.S., then read a paper on "Lunar Objects Suspected of Change."

The Spectrum of Hydrogen.—Prof. A. Herschel read Mr. Schuster's paper on the "Spectrum of Hydrogen," stating that the author thought the second spectrum to be due to some hydrocarbon taken up from the india-rubber tubing, from grease, or from impurities on the surface of the glass; and describing experiments, with chemically-clean vacuum-tubes, in which an alteration of the spectrum occurred.

Spectral Rays.—Prof. Clifford read the Report of the Committee on "Spectral Rays," arranged upon a scale of wave-numbers.

Astronomical Refraction.—Mr. Forbes, in a paper on "Astronomical Refraction," pointed out the sources of error, in the observation of stars, due to the moisture of the atmosphere, and variation of barometric pressure in two separate places of observation. As an instance of the latter cause of error, he cited measurements taken during one month at Greenwich and Chislehurst, only five miles apart, giving a range of barometric difference of $\frac{19}{1000}$ths of an inch. Thus differences of atmospheric refraction would, perhaps, explain discrepancies in observations of the polar distances of the stars.

A series of mathematical papers also were read, of which obviously we cannot here give extracts.

On a subsequent day Sir Wm. Thomson, F.R.S., gave a summary of the Report of the Tidal Committee, as well as a Report on the Gaussian Constants of Terrestrial Magnetism; and later strongly supported the views of Dr. Carpenter on Oceanic Circulation.

SECTION B.—CHEMICAL SCIENCE.

President.—Dr. J. Hall Gladstone, F.R.S., F.C.S.

Vice-Presidents.—Prof. F. A. Abel, F.R.S., F.C.S.; Prof. Williamson, F.R.S.; J. H. Gilbert, Ph.D., F.R.S.; Sir Benjamin Brodie, Bart., F.R.S.; Prof. G. C. Foster, F.R.S.

Secretaries.—Dr. Mills; W. Chandler Roberts, F.C.S.; Dr. W. J. Russell, F.R.S.; T. Wood, Ph.D.

The Inaugural Address of the President opened with an admirable estimate of the position of Chemical Science as a science and as a means of education. He thought that chemistry was rapidly approaching the status of an exact science,—that the chemist stood hourly more in need of the mathematical training necessary to the physical inquirer. The relation of many branches of physics to chemistry was very close, as instanced by spectroscopy and electro-chemistry. The President then stated that he considered chemistry to be an essential branch of the education of every lady and gentleman. Yet he thought the so-called educated classes in England were supremely ignorant of science, and had not arrived even at the first stage of improvement—the knowledge of their own ignorance. The cry of *cui bono* was unluckily too prevalent, and the assistance offered to young and aspiring experimentalists, though great, was ineffectual. Dr. Gladstone concluded his Address by alluding to the magnificent liberality of Mr. J. B. Lawes, who has made over his laboratory of Agricultural Chemistry to trustees, and endowed it, for the benefit of science, with the sum of £100,000.

Professor Williamson proposed and Dr. Longstaff seconded the vote of thanks to the President.

Essential Oils.—Dr. Gladstone, Dr. Wright, and Mr. W. C. Roberts, of the Mint, read a paper on the results of their experiments on the composition of some essential oils used in perfumes, in which it appeared that the choice of the sample greatly affected the value of the result.

The Fusion of Arsenic.—Prof. Mallet reported the successful fusion of arsenic in narrow glass tubing (barometer tubing) enclosed in an outer tube of iron, and heated in a charcoal fire. Arsenic thus treated appears, on cooling, as a fused, compact, crystalline mass, of steel-grey colour, and has a sp. gr. of 5·709 at 15° C. The fusing-point is between that of antimony and silver.

Prof. Mallet exhibited also three specimens of meteoric iron from Augusta Co., Virginia.

British Gold Coinage.—Mr. W. Chandler Roberts, the Chemist of the Mint, detailed the precautions taken to ensure accuracy in the preparation of the gold-copper alloy, an account of which has appeared already in these pages.

Decomposition of Water.—On a subsequent day Dr. Gladstone read a paper on the "Mutual Helpfulness of Chemical Affinity, Heat, and Electricity, in producing the Decomposition of Water." Only certain of the metals are capable of displacing the hydrogen of pure water. Pure zinc does not do so, but does so when the chemical tension is aided by the electrical tension set up when the zinc is the positive plate of a voltaic couple. The effect of varying the distance between the plates of zinc and copper was commented upon, and it was stated that the chemical action increased slowly till the plates are within an inch or so of each other; nearer the action increases at a rapidly accelerating ratio. Heat assists the action. Magnesium alone decomposes water, but more vigorously when in contact with copper, upon which some of the hydrogen gas makes its appearance. If a more negative metal than magnesium be employed in contact with an again more negative metal, there is still a deflection of the galvanometer employed to measure the amount of action. The order for pure water seems to be—platinum, silver, copper, iron, tin, lead, zinc, magnesium.

Manufacture of Chlorine.—Mr. Weldon read a paper on his process of manufacturing chlorine by means of manganite of magnesium. The inventor employs a still to yield an absolutely neutral still-liquor, consisting of a mixed solution of chloride of magnesium and chloride of manganese. The liquor is conveyed from the still to an iron pot, whence it is pumped or syphoned into evaporating-pans, and thence again into a blind furnace, where the evaporation is continued to dryness. The residue is then gently heated with access of air, the chlorine of the two chlorides being driven off, partly free and partly as hydrochloric acid, and manganite of magnesium produced. The loss during the process is merely mechanical, the chemical loss being absolutely *nil.*

After this paper Dr. Crace Calvert read an interesting report on bleaching-powders, with the idea of promoting useful discussion.

Ignition of Cellulose by Saturation with Fatty Oils.—Prof. Dewar read a paper, by Mr. John Galletly, on the "Danger of Ignition of Rags, Paper, &c., Saturated with Oil," and it was shown that cotton-waste, saturated with either boiled linseed oil, raw linseed oil, rape oil, Galipoli oil, castor oil, lard oil, or seal oil, and confined in a closed chamber, became, after from 10 hours to 100 minutes, ignited to ash completely, or more or less charred. Sperm oil refused to char the waste. The cause assigned is rapid oxidation, and the author submits that the term "spontaneous combustion" may be objected to for the same reason that Gerhardt objects to spontaneous decomposition produced by oxidation. Heavy oils from coal and shale, chiefly the olefines, prevent this oxidation, even when mixed with a large proportion of fatty oils. Twenty per cent rape oil gave no indication of heat at 17° F.

Precipitation of Silver by Copper.—Mr. Alfred Tribe contributed a paper of great interest on this subject, stating that silver precipitated from its nitrate solution by copper always contained the latter metal. The presence of the copper he considered due to the dissolved oxygen in the silver solutions, or to the absorption of that gas from the air by the produced copper-nitrate during or subsequent to the precipitation.

Dust from Vesuvius.—Mr. George Gladstone, F.C.S., stated that analysis of the dust thrown up by Vesuvius during the recent eruption proved it to consist of aggregations of crystallised quartz, dotted over with the magnetic oxide of iron. By boiling the sand in hydrochloric acid the whole of the iron is removed. None of the samples contained titanium.

Chemical Nomenclature.—Dr. A. Crum Brown read an interesting paper on chemical nomenclature, to which in an abstract we could not do full justice.

SECTION C.—GEOLOGY.

President.—R. A. C. Godwin-Austen, F.R.S., F.G.S.

Vice-Presidents.—Thomas Davidson, F.R.S., F.G.S.; Prof. P. Martin Duncan, M.D., F.R.S., F.G.S.; Rev. Thomas Wiltshire, M.A., F.G.S.; Prof. J. Phillips, M.A., LL.D., F.R.S.; J. Prestwich, F.R S.

Secretaries.—Henry Woodward, F.G.S.; Louis C. Miall; George Scott; William Topley, F.G.S.

The President, in his Address, dwelt upon the richness in interest of the county of Sussex to the geological observer, upon the place of the fresh- and brackish-water formations on the geological scale, and upon the Wealden formation, especially the Wealden formation of the European surface.

Prof. Phillips proposed and Prof. Hull seconded a vote of thanks to the President.

The principal papers read in this Section were as follows:—"The North-East of Ireland," by Prof. Hull, F.R.S.; "The Geology of the Neighbourhood of Brighton," by Mr. James Howell; "The Sub-Wealden Exploration," by Mr. W. Topley, F.G.S.; "On the Distribution of Goitre in England," by Mr. G. A. Lebour, F.G.S.; "On the Discovery of a Zeuglodon in the Beds of the Eocene Formation," by Mr. H. G. Seeley; "On the Investigation of Plates of Coral from the Mountain Limestone," by Mr. J. Thomson, F.G.S.; "On Brachiapoda," by Mr. Thomas Davidson; "Report on Fossil Crustacea," by Mr. H. Woodward, F.G.S.; and a paper "On the Prospect of Finding Productive Coal-Measures in Norfolk and Suffolk," by Mr. John Gunn. All these paper contain too much detail to admit of useful abstraction.

SECTION D.—BIOLOGY.

President.—Sir John Lubbock, Bart., M.P., F.R.S.

Vice-Presidents.—Prof. Balfour, M.D., F.R.S.; John Ball, F.R.S.; John Beddo, M.D.; George Bentham, F.R.S.: J. Cordy Burrows, M.D.; T. Spencer Cobbold, M.D., F.R.S.; Prof. Flower, F.R.S.; Col. A. Lane Fox, F.G.S.; Dr. Hooker, C.B., F.R.S.; J. Gwyn Jeffreys, F.R.S.; J. Burdon Sanderson, M.D., F.R.S.; Prof. Wyville Thomson, M.D., F.R.S.

Secretaries.—Prof. Thiselton-Dyer; H. T. Stainton, F.R.S.; F. W. Rudler, F.G.S.; J. H. Lamprey; Dr. Gamgee, F.R.S.; E. Ray Lankester; Dr. Pye Smith, F.R.S.

The President opened the proceedings by reading the usual Address. He pointed out the place that natural science should occupy in the curricula of the schools, and then went on to say that the Darwinian theory of the Origin of Species was much misunderstood. Mr. Darwin had called attention to a *vera causa*, had pointed out the true explanation of certain phenomena; it was quite another thing to assume, as was too often done, that all animals were descended from one primordial source. Passing on to consider the valuable work done at Kew, the President said that any change would be calculated to affect its completeness or impair its scientific character.

Dr. Carpenter proposed the vote of thanks to the President.

Mr. Spence Bate then read the Fourth Report of "The Marine Fauna of the South Coast of Devon;" Prof. Newton contributed a paper on "The Extinct Birds of Mascareen Islands;" Mr. J. Robertson a paper on "The Pholades;" and Dr. Dhorn a Report on Zoological Stations.

On subsequent days papers on Zoology and Botany, Anatomy and Physiology, and Anthropology, were read, but are of too technical a nature to be abstracted.

SECTION E.—GEOGRAPHY.

This Section was under the presidency of Mr. Francis Galton, F.R.S., F.G.S., F.R.G.S.; and as the main subject was the discovery of Dr. Livingstone, now perfectly familiar to our readers, we pass on to the consideration of the proceedings of the next Section.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

President.—Prof. Henry Fawcett, M.A., M.P.

Vice-Presidents.—Sir John Bowring; Grant Duff, M.P.; Sir James K. Alexander; Right Hon. J. G. Dodson, M.P.; James White, Esq., M.P.; R. Dudley Baxter, M.A.; William Newmarch, F.R.S.

Secretaries.—J. G. Fitch, M.A.; Barclay Phillips.

Professor Fawcett, in his Inaugural Address to the Section, considered the present rise in prices, and the incompatibility of this rise with the possession of a fixed income, the caution with which a man should leave only a fixed income to his widow and children, when he has other means of disposing of his money, and the time that must necessarily elapse before the incomes of the clergy and others at fixed rates can be advanced to meet essential requirements. The danger of limiting the liberty of the subject by over-legislation, with the view to the amelioration of the condition of the poorer classes, was the subject finally discussed.

Sir John Bowring, who proposed a vote of thanks to the President. then read the Report of the Committee on Uniformity of Weights, Measures, and Coins; and Mr. Burgess a paper on International Coinage.

On subsequent days papers were read upon—"Our National Accounts," by Mr. Frank P. Fellowes, F.S.S.; "The Education of Women," by Miss Emily A. Shirreff; "On Preserved Meats," by Dr. Edward Smith; and "The Pollution of Rivers," by Major-General Sir James E. Alexander, F.R.S.E.

SECTION G.—MECHANICAL SCIENCE.

President.—F. J. Bramwell, C.E.

Vice-Presidents.—John Hawkshaw, F.R.S.; C. W. Merrifield, F.R.S.; Charles B. Vignoles, F.R.S.; W. J. Macquorn Rankine, LL.D., F.R.S.; James Nasmyth, F.R.S.; W. Froude, F.R.S.

Secretaries.—H. M. Brunel; P. Le Neve Foster, M.A.; John G. Gamble, B.A.; James N. Shoolbred.

The President, Mr. F. J. Bramwell, in his Address, dwelt chiefly upon the subject of "Coal," as being that, at the present time, most prominent in the minds of the public at large,—if for no other reason than this, that the steam-engine is still the very crowning glory of mechanical engineering, and that coal is the staff of life, and, so to speak, the breath of the nostrils of the steam-engine. It was pointed out that the supply of coal is a finite quantity; that, unlike the fuel wood, which grows year by year to replace the annual consumption, the fuel coal is given to us once for all; that we are therefore dealing with a store that knows no renewal; that if we waste it the sin of that waste will be visited on our children; and that it becomes us to look upon coal as a most precious, valuable, and limited deposit, of which we are the stewards and guardians. Mr. Bramwell then reviewed the other sources of power within our reach, namely, the wind, the power of our streams, and the power derivable from the rise and fall of the tide.

The most important paper read before this Section was one by Mr. F. Ransome, on "Artificial Stone," to which we shall refer more fully on a future occasion.

Breech-Loading Small Arms.—Mr. Merrifield read a paper, presented by Mr. A. Wylie, of Birmingham, on the "Progress of Invention in Breech-Loading Small Arms during the past Twenty Years," with comments on the Reports of the Small-Arms' Committee.

Aërial Navigation.—A paper on this subject was read by Mr. C. A. Bowdler, who wished to see experiments with aërostats attempted with a view to the introduction of these machines into military tactics. The author believed in the practicability of aërial navigation by simple mechanical means. Manual propulsion having been secured, the power of direction was the next desideratum, and was accomplished by rotating the balloon to any required position, by a rudder, consisting of a vertical disc fixed in a line with the axis of the propeller. By turning the plane of the disc, the current of air forced from the fan on the rudder caused the whole machine to rotate right or left, as in the case of a ship.

Deep-Sea Soundings.—Sir Wm. Thomson, F.R.S., gave the results of some experiments on deep-sea sounding, the weight or load being sustained by a steel-wire of No. 22 gauge. The experiments had been made at a depth of 2700 fathoms, and had been attended with perfect success.

Lights at Sea.—Sir W. Thomson contributed a second paper on "The Identification of Lights at Sea," recommending a system by which light-houses could be recognised by means of signals in accordance with the Morse alphabet.

Measurement of Waves.—A novel paper was contributed on this subject by Mr. C. W. Merrifield, F.R.S., Principal of the Royal School of Naval Architecture, who considered it desirable to confine the measurement to the two points of ascertaining the aggregate height of the waves and their number during measured intervals of time. The machinery could consist of a float sliding up and down strained wires, at the head of a pier or in a standard of framework. A line from this float could pass over a pulley, the motion of which, transmitted through its shaft, would give all the required measurements. The measurement of the aggregate height of the waves would be effected by simply connecting a ratchet-wheel, pawled so as only to turn one way, with the float pulley. To count the waves it would be necessary to record the number of times the float reversed its motion, the record being effected with a pencil on a slip of Morse paper.

Other papers of interest were read, but their application is too technical for abstraction.

Next year the British Association will meet at Bradford, under the presidency of James Prescott Joule, L.LD., F.R.S.

PROGRESS IN SCIENCE.

MINING.

It was stated in our "Chronicles" last quarter, that Archer's Wood was the site selected by the Sub-Wealden Exploration Committee for their experimental boring. But, as it was found that the geological features of that locality would seriously interfere with the work, the operations have necessarily been transferred to a new site. A beautiful spot in Councillor's Wood, in the parish of Netherfield—the property of J. C. Mappin, Esq., who has most liberally given the site—has finally been pitched upon: here the plant has been erected, and the boring commenced under the direction of Mr. Bosworth, an experienced boremaster from Leicestershire. The neighbouring rocks are the shales and limestones of the Ashburnham beds, or lowest members of the Wealden series. It is proposed that the bore-hole shall be 9 inches in diameter, and shall be carried, if necessary, to a depth of 2000 feet. As soon as a sufficient depth is attained, and the rods therefore become heavy enough, it may be expected that good cores of rock may be drilled out; and these 9-inch cylinders will, of course, yield much information to the geologist. Soon after the commencement of the boring, a large party from the British Association visited the works, but the hole was then only a few inches in depth, and the rock was churned up into a kind of mud. Scientific addresses on the object of the exploration were delivered on the spot by Mr. Prestwich, F.R.S., Mr. W. Topley, and Mr. H. Willett, whilst Mr. Bosworth, the engineer, explained the mechanical details of boring. It cannot be too widely known that this undertaking is a purely scientific experiment, for the purpose, mainly, of ascertaining what older rocks occur beneath the Wealden beds in this locality. Reasoning from well-known geological data, it is expected that some of the secondary formations will be either entirely absent or but feebly represented, and that a ridge of palæozoic rocks will be reached at a moderate depth. Those palæozoic rocks, when found, may or may not contain coal; if productive coal-measures be struck, so much the better; but. in either case, the great object of the boring will be accomplished. There seems, however, to be a popular notion afloat, that this is really a trial-sinking for coal in Sussex—in fact, a kind of commercial mining enterprise. No doubt many of the subscribers to the Exploration Fund take this view of the undertaking, but the geologists, who have set the work afoot, lend little or no support to such an inference. It is nevertheless true, that though coal-measures may not be found at this spot, the evidence there obtained may lead to a successful search for coal elsewhere in the south-east of England. Anyhow, the Netherfield boring is a work of great scientific interest, and reflects the highest credit on Mr. Willett, the spirited projector of this enterprise.

Although we may never be able to burn Sussex coal, it seems likely that Sutherlandshire coal may soon find its way into the market. Since the days of Elizabeth, it has been known that deposits of coal exist in the neighbourhood of Brora, on the east coast of Sutherlandshire—not the true fuel of the palæozoic coal-measures it is true, but a very fair coal of oolitic age. These deposits have not been worked for many years, but the present high price of coal has again turned attention to the Brora fuel, and Mr. Jones, of Shropshire, has been employed by the Duke of Sutherland to report upon the Sutherlandshire coal-field. Acting on this report, the Duke is about to renew workings; an engine is to be immediately erected for pumping water from the old pits, and a new experimental shaft is being driven at a place called Strath Steven, on the sea-shore, about one mile east of the old works.

Anyone interested in the development of the mineral resources of Queensland should read the excellent paper by Mr. R. Daintree, published in the August number of the "Journal of the Geological Society"—a paper which may be advantageously studied in connection with the fine display of mineral products exhibited in the Queensland annexe to the International Exhibition. In the south of the colony, extensive beds of coal occur in lacustrine strata, apparently of mesozoic age; and in addition to these secondary coals there is a northern coal-field of even greater extent, which is supposed to belong to the true coal-measures of palæozoic age. The coal of each period is characterised by a distinct flora, *Tæniopteris* being the characteristic fossil of the mesozoic and *Glossopteris* that of the palæozoic coal-measures. Auriferous veinstones are extensively worked in Queensland, both in Devonian strata and in metamorphic rocks. It is interesting to learn, that throughout the whole extent of the great Devonian area in the colony, no rocks have yet been found to include auriferous reefs which will pay to work, except where the strata have been disturbed by intrusion of certain trap-rocks, either diorite, diabase, or porphyrite. The gold from these veins is always alloyed with a large percentage of silver. Thus, a specimen of so-called "spider-leg gold"—that is, native gold with a filiform structure and a semi-crystalline surface—yielded 89·92 per cent of gold, and 9·69 of silver. It seems clear, from the structure of the veinstones, that they have been formed by hydrothermal action, but it is difficult to conjecture how the gold and silver could have been simultaneously precipitated from a state of solution so as to form a homogeneous alloy. In the Canoona Diggings, gold has been found in serpentine. Some rich copper lodes have been worked in the metamorphic rocks, especially at Peak Downs and Mount Perry, while stanniferous granites of extraordinary richness have been discovered in the neighbourhood of the Severn River. One of the most valuable features of Mr. Daintree's memoir is the large number of analyses of local rocks which it contains. These are not only of great service to the geologist, but, in many cases, may also be of much use to the miner; for every practical man believes that the character of the "country" is closely related with that of the mineral veins by which it is traversed.

Attention has been lately directed to the mineral resources of Newfoundland, and the best means of effecting their development. Valuable deposits of lead ore occur on the shores of Placentia Bay, and have been worked at the La Manche mine. Copper ore is found in association with serpentine rocks, and workings have been carried on at Tilt Cove mine, south of Cape John. The copper ore is said to be here intersected by a vein of nickel. Coal appears to be abundant in the neighbourhood of St. George's Bay, and fine marbles are common in many parts of the island.

The results of Mr. Mark Fryar's mineral explorations in the Mergui district of Tenasserim have been published in India. One of the most remarkable features of interest to the miner is the wide distribution of tin ore, in the shape of detrital matter from stanniferous rocks. It appears, indeed, to be almost universally distributed through the river gravels of the country, and Mr. Fryar believes that a thorough examination of the hills through which the rivers flow might be rewarded by the discovery of rich veins of tin-stone.

About twelve months ago, a thermal saline spring was noticed by some miners working in the 160-fathom level of Wheal Seton, in Cornwall. As operations were suspended at that part of the mine, no further notice was taken at the time; but on recently resuming the workings, it was found that the temperature of the spring had increased and the flow of water had augmented. Between 40 and 50 gallons of water were discharged per minute, at a temperature of nearly 100° F., while the air in the closed end was heated to more than 90°. On evaporation, the water leaves a white saline residue. A sample examined by Mr. S. T. Rose, chemist of the Truro Agricultural Association, contained more than 1000 grains of saline matter in the imperial gallon. The spring occurs in a great cross-course, at a distance of between three and four miles from the sea. It is supposed by local miners that the heat of the spring betokens the presence of a strong lode somewhere in the neighbourhood.

Singing-flames, instead of being merely used for pleasing acoustical experiments, promise to become of value to the collier in warning him of danger in the pit. An ingenious application of such flames to the construction of a new safety-lamp has been made by Dr. A. R. Irvine, of Glasgow. When a mixture of an inflammable gas and air, in such proportions as to be explosive, is ignited on the surface of wire-gauze, and a suitable tube or chimney is placed over the flame close to the gauze, a musical sound is distinctly heard, varying in pitch with the magnitude of the flame and proportions of the chimney. Applying this principle, Dr. Irvine has constructed an improved safety-lamp. While the atmosphere is not vitiated by fire-damp, the lamp burns quietly; but when the quantity of inflammable gas rises to explosive proportions the flame emits a musical sound, and thus the danger appeals to the ear, just as in Davy's ordinary lamp the combustion of the explosive mixture within the gauze cage appeals to the eye. Several forms of the singing-lamp have been devised. In one form, adapted to the use of the viewer, the air gains admission near the top of the lamp, while in another form, adapted to the purposes of the working miner, a brilliant light is obtained by the use of paraffin oil.

From an official report recently issued by a special committee appointed by the War-Office to enquire into the subject of the transport and storage of Lithofracteur, it appears that the committee, whilst fully admitting the safety of the explosive under ordinary conditions, find that, on exposure to a high temperature, part of the nitroglycerine separates from the solid substance by which it was absorbed, and exudes from the cartridge. The explosion of a single drop of the pure nitroglycerine might determine the explosion of the entire charge. It appears, then, that lithofracteur cannot be said to be a perfectly safe mining explosive.

It is said that no fewer than twenty-two distinct forms of machine for rock-boring have been constructed by Messrs. McKean and Co. The "McKean Rock Drill"—the final result of their labours in modifying the Haupt Drill—has lately been in successful operation on hard Scotch granite, in which it has been drilling holes 2 inches in diameter, at the rate of about 6½ inches per minute. For use in the mine, the drill is mounted on a vertical column fixed rigidly by a telescopic and screw adjustment. The boring-tool is securely fixed to a solid piston moved by steam or compressed air, and kept working in suspension, the valve-ports being opened and closed so as to leave a cushion at each end of the piston in its reciprocating movement. During the back stroke of the piston, a rotatory motion is imparted to the boring-tool.

That coal-cutting machinery has not been more extensively introduced into our collieries seems to be due, in great measure, to the enormous cost of laying down pipes from the surface to convey the air into the pit, and thence to the part of the workings where the machine happens to be in use. This difficulty may be to a great extent overcome by a recent invention patented by Mr. E. T. Simpson and Mr. F. Hurd. These gentlemen propose to use a portable air-compresser, which may be worked in any part of the mine by manual or animal power.

A correspondent of the "Mining Journal" offers for public competition a prize of £20 for an essay containing the best description of the principal machines and tools used in general mining and quarrying operations, with the results of the writer's experience in their use.

At the recent Cornwall Polytechnic Exhibition, some experiments were made with the Burleigh rock-drill, and with a model illustrating Scott's plan for ventilating mines by injecting steam into one of the shafts. Among the other exhibits were a model of Willoughby's Spring Stamps, one of Borlase's patent ore-dressing machines, and an improved pulveriser by Mr. Sara, of Redruth.

METALLURGY.

From an analysis recently published in the "Chemical News," it appears that a pure wrought-iron has lately been made on a large scale at the Bowling Iron Works, at Bradford, by the Henderson process. The wrought-iron contained 99·5 per cent of iron (by direct determination), with 0·272 per cent of carbon, and the barest traces of sulphur, whilst phosphorus, silicon, and manganese were entirely absent.

The manufacture of charcoal-iron has just been resumed in South Staffordshire. On the same site as that originally occupied by one of the earliest charcoal furnaces in the county, Mr. Light has recently erected a furnace and blowing-engine for the make of charcoal pig-iron, and other furnaces are in progress. The charge is raised in a cage moved by a water balance-lift. The furnaces are blown by an engine having a blowing cylinder above the steam cylinder, and the links connected to the beam working between the two cylinders. By this means the engine works smoothly without a parallel motion. The charcoal-iron run from these furnaces will bear the brand, "Bradley Bridge Charcoal."

Within the last few months the "Barron Steel Process" is said to have been successfully at work in the United States. The cast-iron tools to be converted into steel are first placed in revolving drums, and the rough surface which the castings present as they leave the mould is thus worn smooth by attrition. They are then packed in layers in iron boxes, closely covered with clay, and subjected to the action of oxide of iron or some other decarburising agent. After being annealed in these boxes for a period of from three to six days, the tools are brought into the state of malleable iron, and it only remains to convert them into steel. This conversion is effected by exposing them in a large retort, in the centre of an oven, to the action of certain gaseous compounds of carbon. By this means about a ton of iron tools in the retort may be converted into steel in from eight to ten minutes.

Some improvements in the mode of removing slag from the blast-furnace have been patented by Mr. D. Joy, of Middlesbro'. The slag, as it is run from the furnace, is received into recesses formed on the rim of a cylinder or wheel, and, having been carried through part of a revolution, is discharged from the cylinder. During its passage through the machine, the slag is cooled by a blast of cold air, or by both air and water, the water being the waste liquid from the hydraulic machine by which the cylinder is caused to rotate.

At the recent meeting of the Iron and Steel Institute at Glasgow, Mr. John Mayer read a paper on the rise and progress of the Scotch iron manufacture. The author traced the history of the trade from 1760, and, of course, dwelt especially on the discovery of the black-band ironstone by Mushet, and the introduction of the hot blast by Neilson—the two great events which gave such powerful impulses to the development of the iron industry in Scotland.

Two papers on Reversing Rolling Mills were brought forward at the same meeting—one by Mr. J. D. Napier, of Glasgow, and the other by Mr. G. Stevenson, of Airdrie. In the discussion on the comparative merits of the two systems introduced by these gentlemen, opinion seemed to favour Mr. Napier's differential gear, an arrangement which has been successfully employed at the Codnor Park Iron Works in Derbyshire, the property of the Butterley Company.

MINERALOGY.

A new mineral species, apparently of much interest, has been described in the "Chemical News"* by Mr. Hugo Tamm. It presents the form of a dense, crystalline, dark steel-grey powder, consisting of distinct crystals strikingly resembling those of silicon, and having a specific gravity of 12·5. Unfortunately but a very small quantity of the substance has been at the disposal of the analyst, but it has been satisfactorily determined that the mineral contains 88·05 per cent of tungsten, 5·6 of iron, and 0·15 of manganese. There yet remains 6·2 per cent of some undetermined substance, and it is difficult to conjecture what this missing constituent is likely to be. Mr. Tamm is prepared, however, to say that it is not oxygen, or sulphur, or arsenic; but suggests that it may be phosphorus, nitrogen, hydrogen, or even a new element. Should it be condensed hydrogen, the mineral will be of great interest, as the first example of a native alloy containing hydrogenium.

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* Vol. xxv., No. 659; July 12, 1872, p. 13.

After all, the author admits that the deficiency may be due to an analytical error. As tungsten and iron are evidently the main constituents of this mineral, the name *Ferro-tungstine* has been provisionally adopted. Mr. Tamm had indeed proposed that it should be termed *Crookesite*, but it will be remembered by our mineralogical readers that this name has already been appropriated to a Swedish species unusually rich in thallium, described a few years ago by Prof. Nordenskjöld.* Under these circumstances Mr. Crookes suggests that, as soon as the missing constituent be identified, the new mineral may appropriately be designated *Tammite*.

In compliment to the Keeper of Minerals at the British Museum, the name of *Maskelynite* has been bestowed by Dr. Tschermak on a colourless cubic silicate, having the composition of labradorite, from a meteorite which fell at Shergotty in India, on the 25th August, 1865. The maskelynite is accompanied by augite and magnetite. Tschermak has also described a meteorite which fell near Gopalpoor on May 23rd, 1865, and which consists of nickel-iron, magnetic pyrites, chromite, chrysolite, bronzite, and a mineral resembling felspar.

During the Swedish Expedition to Greenland, in 1870, it was observed that many of the holes in the ice were covered at the bottom with a peculiar deposit in the form of a grey powder, often agglomerated into small globular masses. This glacial sand has been examined both microscopically and chemically. It does not possess the characters of a clay, but the main ingredient seems to be a sandy trachytic mineral, for which Prof. Nordenskjöld suggests the name *Kryokonite*. The origin of this ice-dust appears enigmatical: whether it comes from the basalt region near the coast, or from the supposed volcanic tracts in the interior of Greenland, or whether it is of meteoric origin, are questions which the Professor at present hesitates to answer.

Under the name of *Manganophyll*, Herr Igelström has described a new species of mica from the iron and manganese mine of Pajsberg, near Filipstadt, in Sweden. It possesses a colour varying from bronze to copper-red, and appears to crystallise in the hexagonal system. It contains 21·4 per cent of protoxide of manganese, and is hence the richest manganese-mica hitherto known. Manganophyll appears to stand very close to Breithaupt's Alurgite, from the manganese mines of St. Marcel, in Piedmont; and it is likely enough that the two species may be united.

A preliminary notice of a new lead-ore has been published, in Leonhard and Geinitz's *Jahrbuch*, by Dr. Laspeyres. It seems to be a hydrated sulphato-carbonate of lead, a compound entirely novel in the mineral kingdom. The new species was brought from Sardinia by Herr Max Braun, the well-known mining engineer at the Vieille Montagne Company's zinc mines near Aix-la-Chapelle. Unfortunately the name *Braunite* has been appropriated, as every mineralogist knows, to an oxide of manganese; and the Sardinian lead-ore is, therefore, to be called *Maxite*.

Some confusion is likely to arise in the application of the name *Roepperite*, a name which has been lately applied by Dr. Kenngott to denote a manganesian dolomite, described by Roepper, from Stirling Hill, New Jersey; whilst Prof. Brush has independently used the same name to designate a chrysolite containing zinc, described also by Roepper from the same locality, but distinguished by Kenngott as *Stirlingite*.

Another new species has been detected by Prof. Wiesbach, of Freiberg, among the minerals recently raised at Schneeberg, in Saxony. The mineral is an arsenate of uranium and copper, and has been christened *Zeunerite*. It strikingly resembles copper-uranite in its grass-green colour and its crystalline form, but of course differs in being an arsenate instead of a phosphate.

For upwards of thirty years corundum has been recognised at several of the gold-washings in the mountainous countries of North Carolina and Georgia, in the United States. But within the last two or three years, the search for an improved kind of emery has led to the discovery of many new localities of corundum in this region. Some of these localities have been described by Prof. C. U. Shepard. The corundum seems to be found across a stretch of country at least 170 miles long and about 10 miles broad; but it is likely that this zone will be yet much extended. Throughout this region gneiss is the prevailing rock, but the corundum occurs directly in a chrysolitic rock, resembling serpentine.

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* See Quarterly Journal of Science, October, 1867, p. 542.

Some crystallographic studies of the beautiful specimens of *Datolite*, well known from the Bergen Hill Tunnel, in New Jersey, have been described in "Silliman's Journal" by Mr. E. S. Dana. Upwards of 200 specimens have been carefully examined; four distinct types are recognised, and many new forms are described.

Mr. T. D. Rand has described some pseudomorphs of serpentine in form of staurolite, from the neighbourhood of the soapstone quarry, on the north-east bank of the Schuylkill, between Philadelphia and Montgomery counties. Six-rayed stellate forms of serpentine have been found, identical in shape with crystals of staurolite. Mr. Rand also describes the species Hisingerite from the Gap Mine, Lancaster Co., Pennsylvania; and an alkaline incrustation, consisting chiefly of sulphate of soda, from some decomposed mica-schists cut through on the new line of the Philadelphia, Wilmington, and Baltimore Railroad.

An analysis of the mica from the granite of the Adamello group, south of the Ortler, in Tyrol, has been published by M. A. Baltzer. From this analysis it appears to be an iron-magnesia mica allied to Soltmann's lepidomelane and to Scheerer's mica, from the Norwegian zircon-syenite. The Adamello granite was regarded by Zirkel as a diorite, and by Vom Rath as a distinct species of rock, whilst according to Baltzer, it is merely a variety of granite. The same authority has examined the Blegi oolite from Glärnisch, in the Canton Glarns. This is an oolitic iron-ore, evidently deposited from the old Jura sea. Treated with water, it yields a solution containing many of the constituents of sea-water. The saline matter must have been derived from the sea-water included in the mass at the time of its deposition.

Dr. Carl Klein, of Heidelberg, has published in Leonard and Geinitz's *Neues Jahrbuch*, the results of his crystallographic studies on the epidote and apatite of the Sulzbachthal in the Pinzgau.

Extensive deposits of *Cryptomorphite* are said to have been recently found in Nevada. The mineral occurs in large nodules, and is described as having, in many cases, the appearance of French chalk.

ENGINEERING—CIVIL AND MECHANICAL.

Guns and Armour.—On the 5th of last July an important experiment was made with our present system of guns and armour for our ironclads by an attack upon the turret of the armour-clad steamer *Glatton* by one of the 25-ton guns fired from the *Hotspur*. The result of this contest proved that up to the present the art of defence is in advance of that of attack, inasmuch as the vessel attacked came out of the contest free from any material injury. In this respect the present experiment corresponds in its results very much with those obtained by the trials which took place in 1866, when the armour of the *Royal Sovereign* was attacked by the 9-inch 12½-ton gun of the *Bellerophon*, and with the results of the experiment made in 1861 against the cupola gun shield of Captain Coles on board the *Trusty*. In each case the heaviest available artillery was brought to bear against the shield, and in each case the defence proved superior to the attacking force. So far, then, it may be inferred that our present system of armour-plating is sufficient protection against the heaviest artillery that can be brought against it; to what extent it would prove effective against the enormous masses of iron which low pressure guns upon Mr. Bessemer's process might hurl upon it is a question which may perhaps be safely deferred until that system has been adopted.

Railways.—The most important question in connection with railways that has been brought prominently forward during the past quarter is that of the proposed construction of a line along the valley of the Euphrates river, as a means of obtaining more expeditious access to our Indian possessions. This subject has recently been under investigation before a Parliamentary Select Committee, whose report has now been published. This document contains very extensive information regarding all that has hitherto been done with the view of testing the practicability of constructing a Euphrates Valley Railway, and regarding the various alternative lines that have been proposed for connecting the Mediterranean Sea with the Persian Gulf by means of an iron road. The recommendations of the committee are in favour of adopting Alexandretta as the terminus of the proposed line at its Mediterranean end, and the port of Grane for the Persian Gulf terminus; with regard to the latter, however, they think that a local inquiry conducted by competent scientific authorities is needed before finally deciding. With regard to the route, that by the Euphrates is preferred to the Tigris Valley, as being considerably the shorter and the cheaper to make, although the latter route might attract the larger amount of traffic, and would connect itself better with the projected Turkish system. In the absence of any actual surveys it has been impossible to fix any sum as the probable cost of either route, but it is thought probable that the sum of ten millions sterling would be ample to cover the expense of the shorter of the two routes.

From Mr. J. Danvers's annual report on Indian Railways, which has just been published, we learn that there are now in existence in India nine guaranteed railway lines, four of which have now been completed, viz., the East Indian, the Great Indian Peninsula, the Scinde, Punjab, and Delhi, and the Eastern Bengal. The total length of the open lines is 5136 miles, and further lengths aggregating 940 miles are under construction. There are also twelve state railways sanctioned, having a total combined length of 157½ miles. Of these latter four are completed, namely the Nulhattee branch to the East Indian Railway, the Calcutta and South Eastern, the Khangaon, and the Oomrawattee lines. The total length of state lines open is 68½ miles, and 1503 miles therefore remain to be completed at present. Most of the guaranteed lines have a 5-feet 6-inch gauge, whilst the gauge adopted for the state railways is 1 metre, or 3 feet 3⅜ inches; exceptions have, however, been made in the case of some of those lines. The total estimated cost of all lines sanctioned or completed in India amounts to little less than 110 millions sterling, of which about 92 millions have already been expended.

The St. Gothard Railway Company has just concluded a contract with a Swiss contractor, M. L. Favre, of Geneva, for the construction of a tunnel under the Alps between Goeschenon and Airolo. This will be a more gigantic operation than the Mont Cenis tunnel, inasmuch as its length will be 14·8 kilometres, or rather more than 9 English miles. The estimated cost for excavating this great tunnel is 50 millions of francs, or, say, 2 millions of pounds sterling, and the probable time that it will take in execution is estimated at about 8 years.

Tunnels, however, cannot in all cases be adopted by railways requiring to pass mountainous obstructions, and lines laid on steep inclines must then be constructed. The Cantagallo Railway, in Brazil, meets with such an obstacle in the Organ mountains, which intervene between the important coffee-producing district of Cantagallo, situated on a high level, and Caxoeira in the plains, whence a railway already exists to Rio Janeiro. This railway, from Caxoeira across the mountain passes to Nova Friburgo and Cantagallo, is being constructed with the same gauge as the Mont Cenis Railway, namely 1·1 metres, or 3 feet $7\frac{5}{18}$ inches, and that part of it which traverses the coast side of the mountains will be laid with the central rail. In a length of 7¾ miles, this mountain portion of the line rises about 3000 feet, the gradient varying from 1 in 20 to 1 in 12, and being for the greater part of the length 1 in 13, while the curves are of 40 metres, or about 140 feet radius. In descending from the summit level on the Cantagallo side, the mid-rail is dispensed with, the gradients over the 12 miles extending to Nova Friburgo being easy.

The value of light railways, especially for thinly populated districts, has recently formed the subject of a paper, read by Mr. Henry S. Ellis before the Exeter Chamber of Commerce. Light railways are of three kinds, namely—(1.) Those which follow as nearly as possible the surface of the ground, avoiding the hills and the necessities for expensive over or under bridges, and, by travelling at low speeds, avoiding the necessity for expensive signal and other apparatus usually required by the Board of Trade for through lines. The gauge is usually the national one, viz., 4 feet 8½ inches. (2.) The patent narrow gauge railway, invented by Mr. Fell, which, by being constructed on timber supports of different heights, to suit the undulations of the country, avoids, to a great extent, severance of land and expensive cuttings and banks. The gauge of such lines varies from 8 inches to 2 feet. A railway of this description, about a mile in length, has been recently constructed at Aldershot, in 45 days, for the purpose of conveying stores to the Victualling Office. The gauge of this line is only 18 inches, but it is capable of conveying siege guns 7 tons in weight. The cost is about £2000 per mile. (3.) The wire tramway, which, like the Fell system, is mounted on iron or timber supports, to suit the undulations of the country; but it is only adapted for the conveyance of loads not exceeding 10 cwts., and is generally employed for short distances only—250 yards to 3 or 4 miles. One has been constructed as long as 15 miles.

Mr. Ellis then gave some very interesting statements regarding a light railway recently constructed by the Duke of Buckingham, from which the following particulars have been taken:—The cost of the Wotton Railway, including sidings and two goods' sheds (one 25 feet by 25 feet, and one 60 feet by 25 feet), is rather less than £1400 per mile, exclusive of the value of the land. The main line is very nearly 7 miles long. The gradients from Quainton to Wotton are favourable,—two short inclines of about 1 in 78, in opposite directions, being the worst,—and the general inclination being downwards to Wotton, which is 50 feet below Quainton. The gradients from Wotton to Brill are heavy, the ascent being—with one exception, not quite a quarter of a mile—continuous for 2¾ miles, varying from 1 in 100 to 1 in 51. The latter is a quarter of a mile; but an incline of 1 in 64, on a curve of 12 chains radius, for a quarter of a mile, is quite equal to the steep gradient. The total ascent is about 130 feet in this portion of 2¾ miles. The line was commenced on the 8th of September, 1870. The first portion to Wotton was in use on the 1st of April, 1871, and the greater portion of the remainder was brought into use for minerals, agricultural produce, &c., in November: the last quarter of a mile and Brill Station were brought into use last April, and another branch of 1¼ miles in length was in course of construction last May.

Continuous Brakes.—With the extensive development of railway traffic, and the extension of train services on existing lines, the necessity for some more powerful control over the train, when going at high speeds, makes itself more and more felt, especially on heavily worked lines. We have, on more than one occasion, recently noticed the different designs which have from time to time been put forward, with the view of providing an efficient continuous brake throughout the entire train, so that it might be placed under more effective control, by enabling it to be suddenly brought to a stand-still, and so avoid collision or other accidents which are now too often experienced. The best brake of this kind that has hitherto been introduced is that known as the Westinghouse Air-brake, which, although only just introduced into this country, is already in use on some 20,000 miles of railway in America, where it has been applied to 1200 locomotives and 4000 cars. It has already been applied in this country to trains on the London and North-Western, the Caledonian, and the Charing Cross Railways. Mr. Westinghouse's invention consists of three distinct parts:—First, the arrangements for compressing the air; secondly, the appliances by which the air so compressed is conducted along the train, and made available for applying the brakes; and thirdly, the construction of the signalling apparatus. The latter, however, can only be considered as an adjunct to the brake, as it is perfectly complete without it. The first part of the apparatus consists of an air-compressing pump, fixed to the side of the fire-box of the locomotive, having a steam-cylinder and an air-cylinder, by means of which the air is compressed into a reservoir, placed beneath the foot-plate, and having a capacity of about 12 cubic feet. From this reservoir the air is led by a pipe to a three-way cock, placed so as to be conveniently under command by the engine-driver, the two other branches of the cock communicating the one with the atmosphere, and the other with a pipe leading to a duplicate line of pipes running under the carriages the whole length of the train, by which the compressed air is led to the brake machinery. These latter pipes are connected together between the vehicles by means of lengths of india-rubber tubing. Under the tender, and under each carriage to which the brake is applied, is placed an air-cylinder with a piston working inside, the piston-rod from which communicated with a thrust-rod, and through it the pressure of the air upon the piston is applied to the brake gear. By the adoption of a special mode of connection the brakes are left free for application by the ordinary hand apparatus, if necessary. The application of the brakes is effected simply by turning the three-way cock above referred to, so as to admit compressed air from the reservoir into the lines of pipes extending through the train. The air thus admitted into the pipes passes into the cylinders, forces out the pistons, and thus, through the intervention of the thrust-rods and brake gear, exerts the requisite pressure on the brake-blocks. During a recent experimental trip on the South-Eastern Railway—the train consisting of an engine, tender, and six carriages—the brake was first put on at a time when the speed was 30 miles an hour, and the train was stopped in 18 seconds, and in a distance of 149 yards, up a gradient of 1 in 142. The second stop was made on a rising gradient of 1 in 120, the speed being the same as before. In this case the time taken in arresting movement was 16 seconds, and the distance 107 yards. The speed of the train was 55 miles an hour when the third stop was made, on a falling gradient of 1 in 120, the time required from the moment of applying the brake to stopping the train being 32 seconds. On the fourth and last occasion the speed of the engine had been increased to about 60 miles an hour at the moment of putting on the brakes, and the train was brought up in a distance of 400 yards, the road in this case being tolerably level.

Portland Breakwater.—The completion of this magnificent work was inaugurated by His Royal Highness the Prince of Wales, on Saturday, the 10th day of August last. So far back as 1794 the first conception appears to have been entertained of the advantages that would be derived from the construction of a breakwater at Portland, but it was not until fifty years afterwards that any active steps were taken towards the accomplishment of that object. In 1847 an Act was passed authorising the construction of the breakwater, and the preliminary works were commenced in the same year. The work of constructing the breakwater was practically commenced in 1849, from designs by the late Mr. Rendel, Mr.—now Sir John—Coode being the resident engineer. On the 25th of July, in the same year, the Prince Consort laid the foundation-stone, and ten years later the works were so far advanced as to afford a safe anchorage during a storm. The Portland breakwater works commence with a pier, which starts from the island of Portland near the point where it is connected with the mainland by the Chesil Bank. This pier runs due east for a length of about 1900 feet, at which point there occurs an opening 400 feet wide, and having a minimum depth of 45 feet, to admit of the entrance of ships of war of the largest class from the southward. On the other side of this opening the breakwater proper commences, and is carried out to sea for a distance of 6000 feet, from its starting-point.

The pier, or inner breakwater, consists of a rubble mound, composed of stones of all sizes. After the mound had been consolidated, a trench was excavated within it to the level of low water at spring tides, and a wall of masonry was erected therein. The face-courses of this wall, up to 6 feet above high-water level, are hewn granite. The sea-wall is strengthened by counterforts, 20 feet apart, and connected by arches, so that a platform is obtained 15 feet in width, exclusive of the footway and the parapet. The breakwater proper is simply a rubble bank, the material of which it is formed being for the most part the "cap-stone," which covers the valuable Portland stone, but which of itself is valueless, except for this purpose.

The total length of the whole work is about 1⅝ miles, the width of the structure at the base being 300 feet, at low-water level from 90 to 100 feet, and at the top 60 feet. The average height from the bottom is 70 feet. The sheltered area afforded by these works is about 2100 acres in extent up to low-water line. Connected with the works are two forts, an inner and an outer one, placed one at the end of the pier and the other at the end of the breakwater proper. The inner fort is 100 feet in diameter, mounts 8 guns, and stands in 9½ fathoms of water. The outer fort, on the North Head, has a rubble base, 45 feet high, and containing 140,000 tons of stone. The diameter of the fort is 200 feet, and it stands in 10 fathoms of water.

Vienna Exhibition.—On the 1st of May, in next year, an Universal Exhibition is to be held at Vienna, which, from the dimensions proposed to be given to the building, bids fair entirely to eclipse all former Exhibition buildings, the space devoted for it being no less than 2,783,809 square yards. These proportions will be better appreciated by a comparison with the areas covered by former Exhibitions, which were as follows:—

London (Hyde Park), 1851	94,000	square yards.
Paris (Champs Elysées), 1855	123,214	,, ,,
London (Brompton), 1862	222,316	,, ,,
Paris (Champ de Mars), 1867	527,645	,, ,,

The design for the Vienna Exhibition building is due, we understand, to Mr. Scott Russell. The central part of the building consists of an imposing iron rotunda, or dome, with an outside diameter of 353·68 feet, and a height of 275·5 feet. A conical iron roof, rising to a height of 158·09 feet, is supported by 31 iron columns, each 79·99 feet in height. This conical roof carries an iron lantern, having an outside diameter of 106·27 feet, and a height of 32·8 feet up to the roof, which latter rises 24·27 feet. Upon this is placed another structure, 26·2 feet in diameter and 60·6 feet high. The whole space covered by the rotunda has an outside circumference of 1111·20 feet, whilst the inside circumference is 1038·28 feet, having an available space of 9722·28 square yards. The rotunda communicates with the main gallery, or nave, which has a width of 82 feet and a total length of 2968·4 feet: this nave is crossed, at equal distances, by 16 cross naves, 49·2 feet wide and 672·4 feet long, creating thus, at both sides of the main gallery, 24 courts, which are enclosed at three sides, and which have the same length as the cross nave and a width of 114·8 feet.

MEETINGS OF SOCIETIES.

Mechanical Engineers.—The Institution of Mechanical Engineers held their Annual Meeting at Liverpool, under their President, Mr. C. W. Siemens, on the 30th of July last and following days. In his Address the President referred principally to the question of economy of fuel, which, in the presence of ever-increasing demand and of failing supply, is rapidly rising into a question of national importance; and he remarked that it would not be difficult to prove that—in almost all the uses of fuel, whether to the production of force, to the smelting and re-heating of iron, steel, copper, and other metals, or to domestic purposes—fully one-half of the present enormous consumption might be saved by the general adoption of improved appliances which are within the range of our actual knowledge.

The papers read at this meeting were as follows, but space will not admit of any more full reference regarding them:—

1. "On the Progress effected in Economy of Fuel in Steam Navigation, considered in Relation to Compound Cylinder Engines and High-Pressure Steam," by Mr. F. J. Bramwell.
2. "On the Application of Water Pressure to Shop Tools and other Engineering Works," by Mr. Ralph Hart Tweddell.
3. "Description of Coal-Cutting Machinery with Rotary Cutter, worked by Compressed Air," by Mr. Robert Winstanley.

4. "On Buckholz's System of Decorticating Grain, and making Semolina and Flour by means of Fluted Metal Rollers," by Mr. W. Proctor Baker.

Iron and Steel Institute.—The fourth Provincial Meeting of the Iron and Steel Institute was held this year in Glasgow, at the beginning of August last, under the presidency of Mr. Henry Bessemer. In his Address the President dwelt upon the various centres of iron manufacture which the Institute had successively visited, and the special branches of the manufacture for which each had become famous. The following papers were then read and discussed:—

1. "On the Geological Survey, and the Geological Position of the Coal and Ironstone Strata on the West of Scotland," by Mr. James Geikie, F.R.S.E.
2. "On the Rise and Progress of the Iron Manufacture in Scotland," by Mr. John Mayer.
3 and 4. "On Reversing Arrangements for Rolling-Mills," by Mr. Graham Stevenson and Mr. R. D. Napier.
5. "A new Miners' Safety-Lamp, for Indicating by Sound the Presence of Explosive Mixtures of Gas and Air, based on a new form of Singing Flame." by Dr. A. K. Irvine.
6. "On the Rise and Progress of Iron Steam Ship-Building on the Clyde," by Mr. D. Rowan.
7. "On Lauth's System of Rolling Iron by Three-High Rolls," by Mr. Lauth, of Pittsburg, United States.
8. "On Further Improvements in Spencer's Rotary Puddling Furnace," by Mr. Adam Spencer.

LIGHT.

An alcoholic solution of fuchsine introduced into a hollow prism produces a highly anomalous spectrum, which, instead of proceeding regularly from the red to the violet, like the ordinary solar spectrum, stops at a certain point, returns backward, then stops again, and resumes a direct course to the end.

Drs. Zöllner and Vogel have succeeded in measuring the velocity of the sun's rotation by means of the spectroscope. The value obtained for the motion of a point on the sun's equator is 0·42 German mile per second from one series of observations, and 0·35 mile from a second. This new application of the spectroscope visibly recording the sun's rotation will develope great interest, and we are sorry that the method of observation cannot be given shortly.

Prof. Young has observed some peculiar phenomena relating to vision whilst pursuing a series of experiments. He writes as follows:—"In the course of some experiments with a new double-plate Holtz machine, belonging to the college, I have come upon a very curious phenomenon, which I do not remember ever to have seen noticed. The machine gives easily intense Leyden-jar sparks, from 7 inches to 9 inches in length, and of dazzling brilliance. When, in a darkened room, the eye is screened from the direct light of the spark, the illumination produced is sufficient to render everything in the apartment perfectly visible; and what is remarkable, every conspicuous object is seen twice at least, with an interval of a trifle less than one quarter of a second—the first time vividly, the second time faintly; often it is seen a third, and sometimes, but only with great difficulty, a fourth time. The appearance is precisely as if the object had been suddenly illuminated by a light, at first bright, but rapidly fading to extinction, and as if, while the illumination lasted, the observer were winking as fast as possible. I see it best by setting up, in front of the machine, at a distance of 8 or 10 feet, a white screen having upon it a black cross, with arms about 3 feet long and 1 foot wide, made of strips of cambric. That the phenomenon is really subjective, and not due to a succession of sparks, is easily shown by swinging the screen from side to side. The black cross, at all the periods of visibility, occupies the same place, and is apparently stationary. The same is true of a stroboscopic disc in rapid revolution; it is seen several times by each spark, but each time in the same position. There is no apparent multiplication of a moving object of any sort. The interval between the successive instants of visibility was measured roughly as follows:—A tuning-fork, making 92½ vibrations per second, was adjusted so as to record its motion upon the smoked surface of a revolving cylinder, and an electro-magnet was so arranged as to record any motion of its armature upon the trace of the fork; a key connected with this magnet was in the hands of the observer. An assistant turned the machine slowly, so as to produce a spark once in two or three seconds, while the observer manipulated the key. In my own case, the mean of a dozen experiments gave 0·22″ as the interval between the first and second seeing of the cross upon the screen, separate results varying from 0·17″ to 0·39″. Another observer found 0 24″ as the result of a similar series. Whatever the true explanation may turn out to be, the phenomenon at least suggests the idea of a reflection of the nervous impulse at the nerve extremities, as if the intense impression upon the retina, after being the first time propagated to the brain, was there reflected, returned to the retina, and from the retina—travelling again to the brain—renewed the sensation. I have ventured to call the phenomenon 'recurrent vision.'"

Investigations to test the influence of pressure on the spectra of gases have been carried on by M. Cailletet. He fixed two platinum wires in the end of a thick glass tube, into which the gases were passed. The spark from an induction coil connected with three Bunsen elements passed between the wires. At ordinary pressure the bright lines of the spectra of the gases appeared on a slightly illuminated ground, and as pressure was increased they grew brighter; but they by-and-bye became merged in a continuous spectrum, whose brightness also increased with the pressure. At a certain pressure (between forty and fifty atmospheres) the discharge suddenly ceased; and though the battery power was increased, and the distance between the platinum wires reduced to one-half millimetre, it was not possible to obtain the spark beyond this point. It is thus seen that a spark which passes easily in the rarefied gas of Geissler tubes. or the electric egg. meets with considerable resistance in compressed gas. The brightness of the spark at the point beyond which the discharge is unobtainable is 200 times greater than at ordinary pressure.

Dr. Burt's investigations upon the subject of the influence of variously coloured light upon vegetation shows that green light is almost as fatal to vegetation as darkness; that red light is very detrimental to plants, although in a less degree than green light; that although yellow light is far less detrimental than the preceding, it is more injurious than blue light; and that all the colours taken singly are injurious to plants, and that their union in the proportion to form white light is necessary for healthy growth.

M. P. Thomas, acting under instructions from the Paris Society of Civil Engineers, has reported upon the process of the oxygen light of Tessie du Motay. The report simply treats of technical advantages and disadvantages, leaving out of sight the economical question, which is somewhat to be regretted, in view of the indistinct statement of the causes which have led to its removal from some of the streets of Paris where it had been introduced. The conclusions arrived at are the following:—1. Theoretically, the combustion of oxygen does not increase the illuminating power of a given volume of gas. 2. Practically, however, it enables a burner to consume four times the quantity of gas that can be burned in air, without detriment to the utilisation of the light which may be developed. In particular, it utilises the entire luminous capacity of the gases, however rich, and in almost any quantity. Consequently it would be disadvantageous to employ it for ordinary street-lighting, on account of the limited quantity of gas consumed by the burners, the only advantage gained being the beauty of the light, provided the gas is very rich. Here, unquestionably, would arise the objection of expense, from the complication of the apparatus. But it is very advantageous, and the more so in direct proportion to the richness of the gases employed, for great centres of light (sun-burners, &c.), where a large volume of gas is to be consumed without loss.

Prof. Morton writes to say that, from information received from Dr. Schellen, it would appear that M. Duboscq had previously been the maker of an apparatus for projecting horizontal objects, which involved all the essential features of the vertical lantern described by Prof. Morton in an earlier number of this Journal (p. 396, July, 1872), the apparatus constructed by M. Duboscq being, however, entirely unknown to Prof. Morton.

MICROSCOPY.—A new instrument for making microscopical drawings is described by Mr. Isaac Roberts, F.G.S., in the "Monthly Microscopical Journal," vol. viii., p. 2. It consists of an adaptation of the pantograph used in copying drawings. The smaller ends of the levers carry a thin glass disc, with two cross lines ruled upon it: this is inserted in the eye-piece through a slit in its side, and acts as a pointer; the pencil is attached to the opposite extremity of the levers. When in use, the paper is supported on a desk level with the slit of the eye-piece. The pencil is guided with the right hand, the centre of the cross lines being moved over the object to be delineated while looking through the microscope. This contrivance, although very ingenious, has most probably the defects of the ordinary pantograph, which can only be used with advantage for the reduction of drawings, its powers of execution being defective when used to enlarge, or even to copy, on the same scale.

Mr. Walter White, in "Science Gossip" for August, describes an ingenious machine for cutting vegetable sections. The great novelty is the use of a wedge for raising the substance to be cut, instead of the usual screw with micrometer head. The author claims for his invention the advantages of cheap construction and efficiency. As a cutting instrument, Mr. White recommends a good ordinary razor, fixed in a bradawl handle and carefully sharpened. For cutting transverse sections, the stems—previously prepared by soaking--are fixed in a cork just fitting the tube of the section-instrument; herbaceous stems are best packed in strips of the same stem. Leaves should be placed between the two halves of a cork, cut lengthwise. Seeds, and other small objects, are best cut when bedded in a mixture of wax and spermaceti, formed into a plug by casting in the tube of the section-instrument. Wood for cutting longitudinal sections can be fixed in the same manner. The razor, while cutting, should be kept constantly wetted with methylated spirit, in which stems for cutting are most conveniently preserved until wanted for sections.

Dr. R. H. Ward, in a paper read before the Medical Society of New York, gives a valuable analytical catalogue of the objectives and medical and students' microscopes procurable in England, on the Continent, and in America. The table of objectives comprises those of twenty-seven makers, giving the nominal focal length, angular aperture, and price, with numerous explanatory remarks. This is followed by a synopsis of students' microscopes, in which the advantages and disadvantages of the several patterns of stand, the material used in construction, and the various appendages of the instrument, are all clearly stated. A list of accessory apparatus is given, distinguishing between that absolutely needed and that which may for some special purpose be desirable. The paper concludes with a list of nineteen students' microscopes of American construction, giving name of maker, model of stand, height in inches, weight, diameter of tube, material, adjustments furnished, details of stage, mirror, oculars, objectives, range of magnifying power, accessory apparatus, and price in dollars. It would have been well had this carefully classified table included the instruments of English and Continental opticians, as in the author's list of objectives. The paper is, however, valuable as giving in a convenient form the substance of the catalogues of a large number of microscope makers. The paper is reprinted in the "Monthly Microscopical Journal" for August.

M. Mouchet, in advocating the use of coloured glasses in Microscopy, for the purpose of saving the eye-sight, reviews carefully the various positions in which they may be placed: these are four in number,—before the mirror, under the object, between the objective and eye-piece, and, lastly, above the eye-piece itself. The position before the mirror necessitates the employment of glasses of a certain size, but gives good results, and, when the coloured glass is placed in contact with the flat side of a plano-convex condenser, causes perhaps the minimum loss of light. The tinted glass placed under the object increases the thickness of the mounting, and prevents very oblique light passing through, and also interferes with the use of illuminators, such as the achromatic condenser, &c.; glasses within the body cause trouble and loss of time in fixing and removing them. The most convenient position seems to be above the eye-piece. For this purpose M. Mouchet has constructed a revolving diaphragm pierced with nine openings, each 1 centimetre in diameter. Seven of the openings are fitted with coloured glasses corresponding to the tints of the solar spectrum; another with a silvered glass, according to Foucault's process; and the ninth with a very finely roughed glass, which may be removed at will, and thus leave one opening free. This revolving diaphragm is attached to a ring placed on the tube which receives the eye-piece. Although M. Mouchet considers the apparatus useful in observations by direct sunlight, it seems to have been forgotten that in the employment of condensed sunlight the object needs protection from heat as much as the eye of the observer, and this is effectually done by the cell of ammoniacal sulphate of copper used by Dr. Woodward in modifying the illumination of objects to be photographed by sunlight.

HEAT.

M. Toselli has recently invented a cooling machine, which he terms a dynamic refrigerator. It consists of a revolving disc, formed of a metallic tube bent into a complete spiral, having one end open, and with the other end communicating by a hollow shaft or axis of rotation with an external tube, this communicating with a worm contained in a separate vessel. This worm terminates in a discharge-pipe, having outlet into another vessel containing the revolving disc. The disc is half immersed in cold water, and as the surface of the disc above the water is continually wet, there is exposed considerable evaporating surface. At the same time a stream of water is forced through the hollow spiral, parting with some of its heat under the influence of the evaporation and by radiation, assisted by a current of air from a fan worked by the same motive power. The stream of water lowered in temperature passing through the worm refrigerates the liquid contained in the worm-tub. The decrease in temperature is, to a certain extent, dependent upon the hygrometric condition of the atmosphere. The least effect is a diminution of 4° or 5° F., while the maximum effect in strong sunlight amounts to 32° to 33° F. The invention, if found practicable, will be of great service to the brewer, and to manufacturers, where large quantities of fluid have to be cooled quickly.

Experiments on the joint effect of pressure and heat upon paraffin have been made by T. E. Thorpe and J. Young on the larger scale. 3½ kilos. of paraffin (fusing at 46°, sp. gr. at 13° = 0·906) yielded about 4 litres of fluid hydrocarbons, of which 0·3 litre boiled below 100°, 1·0 litre at from 100° to 200°, and 2·7 litres at from 200° to 300°; there remained a solid residue in the retort, which, on being treated with ether, was found to have as constant melting-point 41·5, and to consist, in 100 parts, of—C, 85·19; H, 15·34. By the action of bromine, this body was found to belong to the $C_nH_{2n}+2$ series. The authors next describe the results of the fractional distillation of these fluid hydrocarbons. After treating the liquids thus obtained with bromine, these substances were found to be—Pentan, boiling-point 35° to 37°; hexan, 67° to 68°, sp. gr. at 18° = 0·6631; heptan, 97° to 99°, sp. gr. at 18·5° = 0·6913; octan, 122° to 125°, sp. gr. at 15·6° = 0·7165; nonan, 147° to 148°, sp. gr. at 13·5° = 0·7279. These hydrocarbons are stated to belong to the series—

$$CH,\text{— - —}CH_2\ldots(nCH_2)\text{— - —}CH_2.$$

To demonstrate the action of water and heat, or of heat only, upon sugar, 200 grms. of sugar and 1000 grms. of water have been kept for some twenty-eight hours at the temperature of boiling water; the optical rotatory power of the sugar has then quite disappeared. Sugar and water have been enclosed in sealed tubes and kept for about thirty days at the temperature of boiling water, with the result that the sugar had become entirely converted into an uncrystallisable compound, probably identical with that which Berzelius and Gelis have obtained by rapidly heating sugar to 160°. By heating sugar for eight days consecutively in sealed tubes in steam of 5 atmospheres pressure (75 lbs. to the square inch, and 153° C.), the sugar is converted chiefly into carameline, $C_{12}H_4O_4$. M. Maumené states that sugar, while being refined or extracted on the large scale, should never be submitted to a higher temperature than 75°, because below that degree of heat sugar is not perceptibly altered.

It is generally admitted that water freezes at 0°, and can only be cooled down below its freezing-point by being kept perfectly tranquil. This holds good for a cold of $-10°$ or $-12°$, but is, according to C. Tellier, not true for temperatures of $-3°$ or $-4°$; because water may be cooled down to these degrees of temperature, and will not freeze, even when the vessel containing it is very violently shaken or stirred. Only a sudden and very violent shock to the vessel will cause the water to become frozen, the temperature rising to 0°; but if, in water cooled down to $-3°$ or $-4°$, the slightest particle of ice or snow is put, congelation briskly sets in and crystallisation ensues, just as in a supersaturated solution of sulphate of soda. Practically this observation is important, as it proves the necessity of water containing ice if it is desired to cool it down to 0° precisely.

Asbestos resists the joint action of friction, humidity, and high temperature, and has therefore been proposed by M. Day as an excellent and durable substitute for hemp or flax in the stuffing-boxes of steam-engines.

The inconveniences attending the application of chloride of zinc and so-called water-glass solution for protection of wood from fire are well known; according to F. Sieburger, it is preferable to first coat or wash the wood twice with a hot and saturated solution of 3 parts of alum and 1 part of sulphate of iron, and next with a more dilute solution of sulphate of iron, to which sufficient pipe-clay has been added to render it as thick as ordinary oil paint. Another excellent method is to repeatedly paint the wood with a hot solution of glue, until a thin coat of glue remains on the surface; then the wood is painted with a thicker solution of glue; a mixture of 1 part of sulphur, 1 part of ochre or pipe-clay, and 6 parts of sulphate of iron, is applied with a dredger, the ingredients having been first separately pulverised and thoroughly mixed.

M. Ch. Mène states that some officers of the Austrian navy have made experiments for causing the smoke arising from the fuel consumed in steamships to be discharged under water by the aid of a blowing machine; at the same time a more active and regular combustion is obtained, and the chances of fire on board greatly lessened, while the funnel or iron chimney, one of the most vulnerable parts above deck, is rendered unnecessary. There is reason to believe that the experiments were in every respect successful.

In order to test whether any bearings or parts of machinery become heated by friction, Dr. Mayer proposes to cover the parts with a thin layer of iodide of mercury, as this red-coloured salt becomes black when exposed to a temperature of about 70°.

We are indebted to M. Collet for an account of the spontaneous combustion of a wooden beam in a building at Ribemont (Aisne). The oak beam was found to be on fire during one of the hot days in the summer; it was directly exposed in an open yard to the concentrated heat of the sun's rays; the combustion, although proceeding slowly, was quite distinct, but was not attended with flame; the smoke, however, had a peculiar appearance, and on blowing the wood it burst into flame. The author asserts that the fire was entirely due to the heat of the sun.

ELECTRICITY.

Captain Hans Busk has designed an electric bell aneroid, which indicates, by ringing one or other of a series of ten different bells, any change in the atmospheric pressure, amounting to 1-10th of an inch on the barometric scale. The mechanism is put in action by a constant battery of twelve Leclanché cells. The bells are arranged in the back of the aneroid case, which is constructed similarly to that of a bracket clock, and to each bell is attached an electro-magnet, with vibrating armature and conducting wires. The dial of the aneroid is formed of a disc of ebonite, 3-16ths of an inch in thickness. In this disc are insulated the steel index of the instrument and sixteen platinum points, forming terminals to the wires from the electro-magnets. To the index-hand is fastened one end of a thin strip of platinum foil. As the hand passes from 1-10th of a degree to another, it brings the platinum foil in contact with one of the platinum points; and, as the hand is one terminal of the battery, the bell corresponding to the platinum point brought into contact is rung, and continues ringing until the hand passes into contact with another point, or until the circuit is broken by a disconnecting switch. In the instrument constructed for Captain Busk by Mr. Browning there are sixteen points, but only ten bells have been found necessary. The object of the inventor was to devise a simple and efficient apparatus which should indicate unerringly, on board ship, or to a person in charge of a lifeboat station, any important approaching alteration in the state of the atmosphere; and it is interesting to note the rapidity with which these changes occasionally suceeed each other.

Prof. Edwin J. Houston contributes the following to the "Journal of the Franklin Institute:"—"Having occasion recently to set up a large battery for experimental illustration of the properties of the voltaic arch, I noticed a fact which I believe has hitherto escaped observation. The battery consisted of about eighty half-gallon cells; fifty-five were Browning's modification of the nitric acid battery of Grove. The negative element consists of sawed strips of very dense coke, the positive element of zinc, so arranged as to use both surfaces of the coke. The remaining cells were of the iron battery. When first set up, the arch between the carbon points measured fully 2 inches, while the flame frequently reached an equal distance above the upper carbon. The quantity of the current was very good—much better, in fact, than the size of the plates would have led me to expect. The phenomenon to which I would call attention is as follows:—"Wishing to show the well-known experiment of the rotation of the light by a magnet, I approached a compound bar magnet to the light, holding it with one end pointing directly to the arch, in a horizontal plane, equidistant between the carbon electrodes. When the nearest end of the magnet was 4 inches from the electrodes, the light was instantly extinguished. The regulator of the light which was employed is a form recently patented by Browning, of London. The carbon points are kept at a constant distance from each other by the action of a small magnet, worked by the battery current. Though inapplicable to small batteries, with the current I employed it gave a light admirable for its steadiness. Thinking that the extinguishing of the light was produced by some cause other than the approach of the magnet, the experiment was repeatedly tried in a number of ways, until it was clearly shown that the cause could not be attributed to accident, but to the approach of the magnet. Though I have failed to find any published notice of this phenomenon, it seems probable that it may already have been observed, as the conditions of the experiment would be almost exactly reproduced whenever the rotation of the light of the voltaic arch by the magnet was tried. Still it may be conceived that, though the necessary conditions for success in this experiment have often been *nearly* produced, they have seldom, if ever, been exactly produced; for it was noticed that in no case was the light extinguished unless the length of the arch was nearly as great as the tension of the electrode admitted; that is, unless the electrodes were separated by nearly their maximum distance, consistent with the passage of the current. Were this condition not observed, in all cases, the approach of the magnet produced no other effect than the rotation of the light, until it assumed a position in a vertical plane 90° from a similar plane passing through the magnetic axis of the bar. Then, again, another necessary condition is that both the tension and the quantity of the current be of a strength greater than that of the current on which the experiment of rotation is generally tried. I have experimented with flames when these latter conditions were absent, and, although the rotation was observed, the extinguishing of the light was in no instance produced. The compound bar magnet employed is formed of three bars, held together by brass screws. It is 1 foot long, 1 inch broad, and ¾ inch thick, and is not at all remarkable for the strength of its magnetism. As to the cause of the phenomenon, I think it may be attributed to the tendency of the flame to rotate on the approach of the magnet. This might cause the extinguishing of the light in two ways:—either by the irregularities on the surface of the carbon electrodes offering greater resistance to the passage of the current from some points than from others, or by the current being unable to pass through the greater distance of the arched path, which is always assumed by the light on the approach of a magnet. Another assumption, which, though perhaps not so simple as those already mentioned, at least as probable, is that on the approach of the magnet there is a slight increase in the non-conducting power of the medium between the electrodes, produced by their polarisation, and which, though always acting, can only manifest itself in a striking manner when the distance between the electrodes is near a maximum and the tension of the current is exerted to the utmost in passing through the non-conducting medium. This assumption of the polarisation of the medium between the electrodes and its consequently diminished power of conducting the current seems to be somewhat sustained by the fact that a powerful electro-magnet, in the form of a horse-shoe, when approached, did not extinguish the light, although it produced rotation of the current; for we may conceive that the two poles acting simultaneously on the medium would neutralise each other's effects. I noticed, on several occasions, that the south pole of the magnet would not extinguish the light until it was approached 1 inch nearer than the north pole, namely, to within 3 inches of the electrodes. This, however, may have been accidental."

Sir William Thomson desires to make known the following case, among many constantly occurring under his notice, of the employment of inferior copper wire in the construction of electrical apparatus. He received lately, from a Glasgow bell-hanger, a large quantity of cotton-covered copper wire, which was being largely used for the coils of electric bells; and upon having it tested very accurately, by means of his new multiple arc conductivity-box, its resistance per metrogramme was found to be no less than 0·439 of a B. A. unit, that of ordinary good copper wire for such purposes being about 0·16 of a B. A. unit.

M. J. Morin has arranged a new sulphate of copper voltaic element, with the view of the application of continuous currents to therapeutic purposes. It has for its object the complete avoidance of the inconvenience which results, in the ordinary sulphate of copper element, from the deposit of zinc either on the copper or the porous cell. It consists of a cylinder of copper, the interior of which is concentric with the cylinder of zinc; the annular space comprised between these two metallic surfaces is divided into two equal parts by a cylinder of filter-paper. Ordinary sandstone is put between the interior surface of the copper and the paper diaphragm, and sublimated sulphur on the side of the zinc; the whole is plunged into a solution of sulphate of copper, which penetrates through the mass, by means of the numerous minute orifices, freely to the copper. Some hundred elements prepared in this manner, and frequently in use, have been set up for more than twenty months, and the alteration which they have undergone shows that this is but half the time for which they may be worked: they have been perfectly closed during this time, and have neither been subjected to repair nor inspection.

Professor Forster, in a recent number of "Poggendorff's Annalen," gives an account of a curious effect observed in a gold-leaf electroscope. He was one day showing to an audience that if the leaves were in a state of divergence through negative electricity, the divergence would be increased on approach of a *negatively* electrified body, and that it would be diminished in the opposite case. To prove this, he had a magnified image of the leaves projected on the screen. He rubbed a rod of caoutchouc with cat-skin, and touched with it the ball of the electroscope. On removing the rod the leaves showed about 70° divergence. He again rubbed the rod, and brought from above towards the electroscope, the axis of the former being at right angles to the vertical axis of the latter. Expecting the divergence to increase, he was surprised to find that it diminished, and on further approach became zero, while it increased on slightly removing the rod. If the rod was withdrawn very slowly the divergence remained zero, but rose again to the former amount as the rod was further withdrawn. Frequent repetition of the experiment gave similar results, only, he remarks, the electrical source must be a pretty powerful one. After various futile attempts to explain the matter, there arose the doubt whether the divergence which appears after making a rubbed caoutchouc rod touch the ball of the electroscope was really due to negative electricity (–E). He became convinced that while the rod is, of course, negatively electrified, yet the leaves diverge with positive electricity (+E). He thus describes his experiments:—"Let a caoutchouc rod be rubbed with cat-skin and brought near the knob of a Fechner electroscope" (in which, it may be explained, there is only one leaf suspended between the opposite poles of a pile). "The leaf then moves to the + pole. The rod is therefore – electrified. Now rub the rod again, and touch with it the knob of the gold-leaf electroscope" (with two leaves). "Then remove the rod. Next, let the knob of this charged electroscope be brought near the knob of a Fechner electroscope (uncharged). The leaf of the latter moves to the – pole; the leaves of the former, therefore, diverged with +E; and thus the electroscope became + electrified through contact with the electrified rod. It remained to ascertain the reason of this fact, which, once ascertained as a fact, removed the difficulty in the first experiment. When the strongly – electrified rod is brought near the knob, there takes place decomposition of the electricity in the electroscope. The +E flows into the knob, in which it is retained by the rod; the –E flows into the leaves, which diverge in consequence. While thus influenced by the rod –E escapes, and there is a progressive collection and retention of +E in the knob. At the moment of contact between knob and rod, the rod communicates the –E present at its point of contact to the knob, and this neutralises in the latter a corresponding quantity of +E. As, however, the excited parts of the rod not in immediate contact with the knob do not give up their –E, this surplus of –E still carries on the decomposition and retention of electricity in the electroscope; so that there comes to be much more retained +E in the knob than –E in the leaves (for a constant waste of –E takes place in the electroscope). If the rod is now slowly removed its retentive influence on the knob decreases, and a certain quantity of –E flows into the leaves, neutralising there a certain quantity of –E. When the rod is just so far removed that as much +E can flow from the knob into the leaves as there is –E in these, the leaves become unelectrified and the divergence zero. On further withdrawal, still more of the hitherto retained +E flows from the knob to the leaves, and now commences a divergence with +E. When the rod is entirely removed, the whole of the hitherto retained +E is free, and produces strong divergence. As the rod is approached again, these phenomena are witnessed in reverse order. This theory rests on the supposition that the +E which has been separated and retained by the rod preponderates over the –E communicated to the electroscope by contact (which is easily understood, as an electrified non-conductor gives up its electricity only at the point of contact). For this preponderance to take place it is necessary, as has been said, that the electric source should be a very active one. It can, further, be easily shown that in such circumstances the –E flows away from the electroscope (without conduction) if the electrified rod be brought near the knob without touching it. In this case no electricity can flow directly from the rod to the knob, and yet, if after a few seconds the rod be withdrawn, the leaves diverge considerably with +E. The explanation is simple. The fact, however, that it is possible, by contact of the electroscope with a negatively electrified body, to obtain + divergence, appears to me one of considerable importance. Thus, supposing, in the absence of a pile electroscope, it were required to determine whether a body rubbed with a certain kind of material became + or – electrified, it would be a very likely method to first cause divergence in the electroscope leaves with a rubbed caoutchouc rod, and then test the electric state of the body in question by its influence on the divergent leaves, and call it + or – accordingly. On the former supposition, that the leaves diverged with electricity of the same sign as the caoutchouc rod, any such judgment would be absolutely false. A + electrified body would be taken for a —, and *vice versa.* Such error might be guarded against if, instead of bringing the caoutchouc rod near the electroscope, a small charge of −E were brought from the former, by means of a proof plane, to the knob of the latter, as the proof plane would not collect sufficient electricity to produce the disturbance observed in the other case."

Mr. Planté has recently described a new form of secondary battery. Two plates of lead (20 inches long by 8 inches wide), are rolled up in spiral, being separated from each other by a few strips of india-rubber. This spiral is placed in a jar containing acidulated water, and having a gutta-percha cover, on which are fitted bending screws connected with the plates. Twenty such elements are placed in two rows of ten each, and charged from the primary battery, which consist of two Bunsen's couples. By means of a commutator of peculiar construction these secondary elements may be connected either for quantity or for intensity. When the elements are joined in series an electro-motive force equal to thirty Bunsens is obtained, giving a current by means of which platinum wire may be fused. In the secondary couples the chemical action generating the current is the reaction of hydrogen on peroxide of lead, the current from the primary battery having caused decomposition of the water oxidising one of the plates, and developing hydrogen on the surface of the other. By the above arrangement the quantity of electric work from the direct action of the primary is transformed by condensation. The case is somewhat similar to that of a hydraulic press or crane. In a pile driver, *i.e.*, a heavy body raised by degrees to a great height, by a series of successive efforts, is then left to itself, and gives back at once the greater part of the work thus expended on it. So, when, after charging, the secondary circuit is closed, the sum of the accumulated chemical actions caused by the primary current is given out in the form of a very intense current of short duration. The effect, when the couples are joined for quantity, corresponds to the fall of a very heavy mass raised a small height; when joined for intensity, to the fall of a small mass raised to a great height.

Mr. W. H. Preece, of Southampton, gives the following information about lightning conductors:—Ordinary galvanised iron wire, known as No. 4, which is ¼-inch in diameter, tipped with a gilded brass point or cone, is amply sufficient for any dwelling-house. It costs about a penny per yard, and the brass cones would cost about sixpence each. Thirty shillings would pay for all the materials required for an ordinary house. The reasons for recommending this wire are these:—When telegraph poles were first erected in this country they were protected with lightning conductors. This practice was subsequently found to be too expensive, and was abandoned. Such "earth-wires" or conductors, were, however, found to effect another and very important object, and their use was continued on all main lines. Mr. Preece says, I have never known a case of a pole so protected being damaged through a thunderstorm, whereas scarcely a thunderstorm occurs without some unprotected poles being injured. I remember, near Romsey, twenty unprotected poles being shattered by one discharge, and upon the Basingstoke and Andover line 15 per cent were found to have been struck. The line was renewed and earth-wired, and not a single case of damage has occurred since, though some years have elapsed. A pole was very recently found in South Wales with 8 inches of its top shattered—the earth-wire only went so far; the charge from that point went harmlessly to earth through the wire. The cross arms are frequently found damaged as far as the earth-wire, never beyond. Instances could be multipled *ad infinitum*, and as the wire used is generally No. 8 (170 inches in diameter), and sometimes even smaller, I think I am fully justified in saying that No. 4 wire, which is twice as thick, and offers half the resistance, is amply sufficient for the protection of our houses. The precautions necessary in fixing conductors are these:—(1) The conductor must be solid and continuous from its gilded point to the ground; (2) Its connection with the ground must be sound and good. It may be connected with the iron, gas, or water mains, or be buried several feet deep in a bed of coke, or be attached to a mass of metal in moist earth, or be carried down a well; (3) Each conductor, if there be more than one, should make a separate earth if possible, and they should all be connected together below the surface. The lead roofing and all external masses of metal should be connected with them; (4) All joints and connections should be soldered. It is better that each chimney stack should have its own conductor, and they should be periodically examined to see that their points remain intact, and that their metallic continuity is perfect. The custom is to fix them, and then to leave them to chance. The precautions that are unnecessary are these:—(1) It need not be copper; (2) It need not be insulated; (3) It need not be carried externally to their disfigurement in the cases of church spires, columns, and chimneys. I never pass Trafalgar Square without regretting the disfigurement of Nelson's statue. It is, however, better to carry the wire externally in the case of dwelling-houses, lest it pass too near the lead gas-pipes, which, being good conductors and soft metal, might be fused. The wire can go round a corner as well as through it, but acute angles are best avoided. The more direct the course to the earth the better. The area protected by a conductor is said to be that whose radius is equal to twice the height of the conductor from the ground; but it is safer to take the radius as equal to the height of the conductor. Thus, for small houses one conductor is enough, but it is safer to attach one to each stack. If it project a yard above the stack it is sufficient, and it is within reach for inspection. The stack pipes down the sides of a house are convenient conduits for the wire, and there is no reason why it should not be carried down to the ground inside them, so as to be out of sight. If there be no convenient stack pipe the wire can be run up and stapled to the brickwork or stone. With thirty shillings for materials and ten shillings for labour any intelligent man can, with these directions and precautions, safely protect his house from the destructive effects of thunderstorms.

Mr. J. Baynes Thompson has shown that common electro-plating is not applicable to steel or iron, as these metals cannot be got perfectly clean, that is, chemically clean; therefore no adhering coating can be obtained. In fact, for all manner of plating or soldering, the first requisite is, that the two metals that are to be applied to each other must be chemically clean, or no proper adhesion can be obtained. This cleanness is obtained in various ways: in soldering by various fluxes; in electro-plating, to such metals as that method is applicable, by dipping the article in an acid which will readily dissolve the metal of which it is made, and not only so, but the salt formed by this solution of the metal in the acid used must be readily soluble in water, or no clean surface can be obtained. There is still another condition to be considered; that is, when the surface of the metal has been made thoroughly clean, it must be protected from contact with the air in its transit from the cleansing-baths to the solution wherein it is to be coated. This condition, not being recognised in the first attempts at electro-plating, caused many failures and much trouble, until it was discovered that a film of mercury prevented the contact of the air with the cleaned metal. Moreover, mercury has the advantage that it amalgamates with the metal to be coated, and with the coating, though this amalgamation is not absolutely necessary; yet it facilitates the coating of metals with other metals by electro-deposition, when the two metals will readily amalgamate. There are cases where amalgamation is not possible; for example, where one of the metals will not amalgamate, as with steel or iron coated with aluminium or nickel; not that it is impossible to form an amalgam with these metals, for even steel can be amalgamated with the intervention of sodium, but it is not possible for plating purposes, as a diluted solution of a mercuric salt must be used. For all such cases as these, where the amalgamation process cannot be used, pyro-plating is employed, this name being given to distinguish the process from the electro-plating process, and because the coating is driven into the surface of the metal on which it is put by means of heat and pneumatic pressure. It is not confined to coating with silver, as its name might indicate, but it is at present applied to coating with gold, platinum, silver, nickel, aluminium, copper, brass, or bronze and aluminium-bronze. The process is very simple, but the details require much care and attention. The end to be obtained is simply this: that the metal to be coated shall be "chemically clean" when immersed in the solution in which it is to be coated. There are several ways in which the attainment of this end may be prevented—by inadequate means for cleansing; by a passage through the air of two or three feet after being cleansed; by the metal being positive in the coating solution—in this case the metal is fouled on contact. This refers to cyanide solutions, to sulphur and chloride solutions, to double sulphates and chlorides, as of nickel and ammonia, and of platinum and potash or soda. All of these may be used in certain cases for pyro-plating, but they are *not* used. There is a special solution used for pyro-plating in all cases, because most of these solutions leave matters on the metal that is being coated if it be in the slightest degree porous or "roaky," as is the case with steel that has been badly faggoted, and on the article passing through the furnace these matters volatilise and cause an irruption in the coating. The amount of metal put on is ascertained by having a test-surface put in with the articles, and the exact time of plating and the exact weight of the test noted. This test is carefully weighed from hour to hour until the amount desired is put on. After being dried, the articles are put into the furnace. The firing-furnace, as it is technically termed, is of simple construction. A bright red heat is required in the chamber where the articles are placed. In firing knife-blades and other cutting instruments, care has to be taken that the heat is not carried higher than 450° and 500° F. This is ascertained by trials on a pad of prepared test-paper; a blade is taken out from time to time and tried upon the pad, and the colour noted—whether the blade scorches it straw-colour, yellow, pale brown, deep brown, or black. After the desired heat is attained, the blade is instantly immersed point downward in cold water, and all that were in the firing-chamber with it. The theory of the process, which is technically termed "burning in," is this:—On the instantaneous immersion in cold water, the coating is seized and retained by the suddenly contracting under metal. This is seen to be the case on filing or grinding the coating from the under metal; for though the coating may be filed or ground off until both coating and under metal are filed or ground off together, yet the under metal remains spotted all over with an infinity of little points, the pores filled by the coating metal.

TECHNOLOGY.

An American engineer recommends the following composition as a cement for leather, wood, &c., resisting the action of water, both hot and cold, and most of the acids and alkalies. Three parts, by weight, of shellac, and one part of caoutchouc are to be dissolved, in separate vessels, in ether free from alcohol, applying a gentle heat. When thoroughly dissolved, the two solutions are to be mixed. If the glue be thinned by the admixture of ether, and applied as a varnish to leather, it renders a joint or seam water-tight.

M. B. Renault has submitted to the Academy of Sciences a new method for obtaining the reproduction of designs. The design is traced with gummed ink upon stiff glazed paper, over which fine brass or bronze powder is dusted. By this means a kind of plate is obtained, admitting of the most varied designs being taken off upon prepared paper. By softening the ink with vapour of alcohol, the metallic powder can be removed when spent by use.

A method of testing petroleum and other inflammable fluids, and also of determining their specific gravity, has been patented in the United States. The apparatus consists of an upright glass cylinder supported in the top of a chamber formed in the upper part of a base or stand. A lamp is placed in the base, the heat from which is transmitted through the chamber to the lower part of the glass cylinder, and the chamber may be made to contain air, water, &c., as required to regulate its intensity. The glass cylinder contains a thermometer, which is fixed therein, and is closed at the top with a brass cover. The fluid to be tested is made to completely fill the glass cylinder, so that the thermometer is entirely submerged and cannot be affected by the surrounding atmosphere. An orifice in the brass cover is opened, to allow the escape of vapour from the fluid under test, and when necessary the lamp is lighted.

A flame is held over the orifice, and at the moment the evolved vapour is ignited the temperature of the fluid is correctly indicated by the thermometer. In ascertaining specific gravities by this instrument, a hydrometer is also placed within the glass cylinder in such a manner that its scale-tube is free to move up or down through a hole in the brass cover. The surface of the fluid tested is plainly visible through the glass cylinder, and the scale may be accurately read.

A so-called rubber-graphite paint has recently been patented, said to be waterproof and to present other advantages of reducing the corrosive influence of exposure to the atmosphere, &c. It is a solution of pure india-rubber in linseed oil, which is ground with graphite into a thick, elastic, smoothly-flowing paint. Compositions of which india-rubber forms a part possess, in a very high degree, the quality of resisting the action of moisture and of corrosive gases. The graphite is a pure form of carbon; and it is well known that paints containing carbon in form last longer than other kinds, holding their body and colour when other paints are totally destroyed. So that the combination may, as suggested, form a paint of great durability and highly-protective qualities. Cream colour or drab paints can be obtained by this method.

An admirable paper on the preservation of wood has been written by M. Hermann Haupt, C.E. in an American contemporary. The experiments show—That so long as the celts of wood are occupied by air and moisture, no preservative solution can be introduced, and the expulsion of air and water must be the first step in any effective process for preserving timber from decay. That water can be expelled by a long-continued application of heat, but air only by expansion in a vacuum, and the combination of heat and vacuum will secure the most rapid expansion both of water and air. The preservative fluid must be introduced while the cells are empty, consequently the process must be carried on *in vacuo*. That no pressure, however great, applied externally to the surface of timber, can force fluid into the interior so long as air or water is contained in the cells. When air alone is present, there may be penetration to a limited extent, superficially, but water is practically incompressible. If, however, the pressure is applied at one end only of a log, as in the Boucherie process, a fluid may be forced through and exude from the other end. An apparatus to fulfil the conditions which, from the preceding discussion, appear to be essential to success, must be founded on a process similar to distillation *in vacuo*. It must consist of at least two vessels—one a receiver corresponding to a retort, in which the material can be placed and subjected to the action of heat; the other a condenser, in which all escaping vapours can be condensed, and the vacuum maintained during the process in both vessels. The condenser may be of much smaller capacity than the receiver; they should communicate by pipes furnished with stop-cocks, and both be supplied with thermometers, vacuum gauges, and pumps. As an illustration, suppose wood is to be impregnated with dead oil or ony other fluid. The receiver must be filled with the wood to be operated on, the door closed air-tight, and the air expelled from both the receiver and condenser. The expulsion of the air may be effected in various ways. Steam may be admitted at one end to drive out the air at the other end; the subsequent condensation of the steam should leave a vacuum, but in the experiments of the writer this plan has been only partially successful. The air may be exhausted by an air-pump, but a perfect vacuum cannot in any way be secured. The vessels may be filled with water, and the water removed by a pump below the level of the bottom into which the water flows. This should remove all the air excepting that which escapes from the cells. As the atmosphere supports a column of water 33 feet high, pipes may lead to a tank at a level about 40 feet lower, where the location is favourable, and thus by filling the vessels with water and opening cocks to allow the water to flow by gravity into the tank, a very perfect vacuum could be produced. This arrangement would be particularly favourable for maintaining a vacuum in the condenser; a pipe in the condenser could throw jets of water in spray from numerous fine perforations, and the water would consequently flow in the tank 40 feet lower, maintaining a constant vacuum without the aid of pumps. This object can be accomplished in almost any locality by placing the condenser at the top of a building or on trestle work. Assuming that a vacuum has been created and provision made for maintaining it during the whole process, the next step will consist in the application of heat, which may be done most conveniently by steam-pipes introduced in the receiver. The length of time during which the timber must be subjected to the baking process will depend upon the dimensions of the logs, and can only be determined by experiment. It is obvious, however, that the circumstances are favourable to the most rapid evaporation possible; the temperature can be regulated at pleasure, and the removal of pressure by vacuum will give a very low boiling-point. As the vapours pass over they will be immediately condensed. Should the vacuum become vitiated by the escape of air from the cells, it may be improved by the use of an air-pump. The condition of the vacuum will be indicated by the gauges. When sufficient time has been allowed for the wood to dry thoroughly, cocks must be opened connecting the bottom of the receiver with a tank of dead oil at a lower level. As a vacuum exists in the receiver, the atmospheric pressure will force up the oil and the timber will be immersed in the fluid. When the immersion has continued a sufficient length of time, which also must be determined by careful experiment, cocks may be opened at the top of the receiver to admit air. The oil not absorbed will immediately flow back to the tank from which it was taken; the air pressing upon the exterior of the cells, which are partially filled with oil, while a vacuum exists in the interior, will force the oil before it, and thus coat in its progress the interior of the cells. It is probable that in this way a sufficient amount of dead oil may be introduced into the cells to prevent fermentation and decomposition while still far below the point of saturation, and the process may prove rapid and economical. Instead of admitting air in the manner proposed to expel the oil from the receiver, it is possible that better results may be obtained by allowing the oil to remain until it becomes heated by the steam coils, and the vapour collecting at the top expels the oil and penetrates the pores. Too much oil might be introduced by this mode of treatment, and it is probable that the introduction of air, followed, perhaps, by a second bath of oil to close the cells superficially and exclude moisture, would give the best results. All these and other questions that may arise can only be settled by experiment.

In China and Japan the rice-paper plant is cultivated upon the hills and high-lying ground. In the autumn of each year, before the leaves fall, the Japanese cut off the young shoots and cut them into slips, which are tied up into bundles and boiled in large copper kettles or cauldrons closely shut down. The boiling is continued until the bark has peeled off the wood, when the former is carefully dried and stored away for future use. When it is required for paper-making it is thoroughly soaked in water for three or four hours, after which the brown skin is scraped off. At the same time the bark which covered the younger shoots is separated from the older and tougher sorts, from which an inferior kind of paper is made. Bark which has been kept for some years is only fit to make the commonest packing paper, and is manufactured with less care. When the bark is well cleaned and arranged in order according to its quality, it is again boiled until the matter separates into a filamentous substance. This boiling is succeeded by another operation, called washing, which is of great importance in the manufacture of paper. If it is not continued long enough the paper will be of coarse quality; and if, on the other hand, the substance does not receive enough boiling, the paper will be very white, but too soft and greasy to write upon. The pulp is placed in a basket which will admit the water on all sides, and this is plunged into a ewer and stirred about with violence for some time. Then the substance is placed upon a smooth table and beaten with wooden rollers. After the beating an infusion of rice is poured upon it, and the mixture is suffered to stand until dry, when the substance is raised leaf by leaf in the form of paper. These leaves are placed between boards, and the remaining moisture gradually pressed out. According to another account the stem is cut into lengths of 10 or 12 inches, and the pith forced out and placed in hollow bamboos, where it swells out to its natural bulk, and dries into a compact mass. This pith is cleverly cut by a workman, who holds a sharp knife against the side of the cylinder, which is then turned round, so that the pith is cut into a broad strip about 4 feet long. This is cut into small squares, and sold in packets for different purposes. It is supposed that the paper made from the pith is the rice-paper which is imported into this country. It cannot be made until the tree has attained a considerable bulk, and is too old to produce many shoots such as are used in the first process. The tree from which this paper is made is particularly abundant in the island of Formosa. It is at first a small shrub, but after flowering it throws out several branches, and grows to a height of about 25 feet. It is generally cut down before it attains its full maturity, because the pith and bark degenerate in the older parts. Several large palmate leaves crown the stem. It has been supposed by many botanists that there are two or three different species of plants from which the Chinese make their paper, and there are apparently several ways of manufacturing it.

An enamel for copper cooking utensils is made by fusing together 12 parts of white fluor-spar, 12 of gypsum, and 1 part borax, dissolving the mass in water to a thick paste, which is applied as a paint to copper vessels, and when dry, this is rendered adhesive by being thoroughly baked.

An alloy, composed of 3 parts of tin, 39·5 copper, and 7·5 parts of zinc, is very well adapted for joining brass or copper to iron and steel.

CHEMICAL SCIENCE.

Mr. A. P. S. Stuart, an American chemist, remarks that everyone who has prepared hydrofluoric acid knows that sulphuric acid and fluor-spar form an exceedingly hard compound, which it is very difficult to remove from a platinum retort. The formation of this hard mass may be prevented by mixing with the fluor-spar about an equal weight of gypsum and the proper quantity of sulphuric acid. After the expulsion by heat of the hydrofluoric acid, the residuum in the retort is found in a pasty condition, easily removed by water.

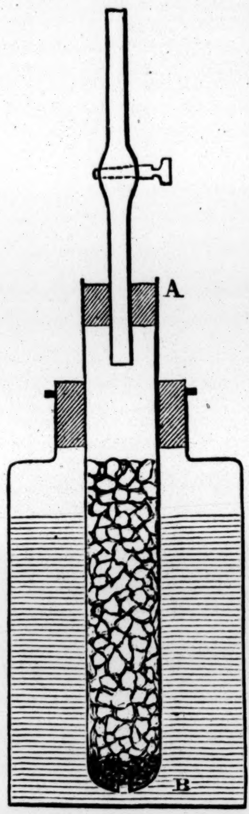
M. Puscher recommends that, to coat zinc with iron, the objects should first be plunged into a hot solution of 160 grms. of ferrous sulphate and 90 grms. of sal-ammoniac in 2500 c.c. of boiling water. After two minutes' exposure they should be removed and brushed off in water. This has for its object simply the cleansing of the surface. They are again placed in the bath and heated, without brushing or washing, until the sal-ammoniac fumes have disappeared, then washed, and this operation repeated three or four times. A coating of iron will be found formed on the zinc, which takes a fine polish when scratch-brushed.

Prof. Bischof has found that the analysis of a clay gives a distinct indication as to its power of resisting extreme heats, on the ground that the value of a refractory clay varies with the proportion of the alumina to the fusible matter, and again with that of the alumina to the silica. The more alumina a clay contains in proportion to the fusible matter (iron, alkalies, &c.), the more refractory is it. Silica, on the contrary, augments its fusibility. Except in certain determinate cases, the clays containing alumina, silica, and fusible matter in equal proportions, have an equal power of resisting fire. If there is taken for clays the general formula—$m\mathrm{Al}_2\mathrm{O}_3+n\mathrm{SiO}_2+\mathrm{RO}$, the degree of resistance to fire is measured by the ratio of $\frac{m}{n}$. The higher the value of this fraction, the more refractory the clay.

In cases where tubes cannot be connected by india-rubber, corks, &c., Mr. Karsten makes a gaslight joint by bending the two tubes to be joined vertically, the lower one capable of sliding within the other. When in this position, the open end of the upper or outer tube is surrounded by mercury retained in a cup, through the bottom of which the smaller tube passes. The whole apparatus is most easily constructed, and can readily be taken to pieces and put together again.

M. J. Boussingault has made some experiments to investigate the condition in which carbon exists in meteoric iron. In the meteoric iron of Caille, 0·12 per cent of combined carbon was detected, while the celebrated Lenarto meteorite was found to contain neither graphite nor combined carbon.

New forms and new modifications of apparatus are constantly being proposed and described for the convenient generation of H_2S, CO_2, and H in laboratory work. Many of these are somewhat complicated and expensive, more or less difficult to fill, and liable to breakage. Mr. William Hutchings advocates a trial of the following application of an old principle:—A large wide-necked jar is provided with a well-fitting stopper of cork or caoutchouc. Owing to the difficulty of boring a large hole in caoutchouc, cork will generally be preferred. In this a hole is bored wide enough to take a piece of large-bore glass tube, A B. This tube is of such a length that it reaches almost to the bottom of the jar, and projects 2 or 3 inches above the stopper. One end of it, B, is held in the gas-blast, and turned round and round till it softens and partially runs together, leaving only a small opening. The other end is fitted with a caoutchouc stopper, through which passes a glass tube of suitable bore with a glass stop-cock, all fitting perfectly tight. The tube reaches a little way below the stopper, and 3 or 4 inches above it, and is connected by india-rubber tube with wash-bottle, &c. The opening at B is covered with lead-shavings, a plug of lead wire, or pieces of glass, to allow the acid to rise into the tube, at the same time preventing any of the bits of marble, zinc, or sulphide of iron falling out. The tube, A B, being filled, is closed by its stopper and stop-cock tube, and inserted through the cork into the jar, which is a little over two-thirds full of the dilute acid. According as the stop-cock is opened, a stream of gas of any required amount is given off, and on closing the cock the acid is all driven into the jar. It is evident that the tube A B must not fit air-tight into the stopper of the jar. The best way of arranging is, after boring the hole in the cork for the tube A B, to cut a little channel with the triangular file, just sufficient to allow of the rise and fall of the liquid in the jar. A jar about 10 inches high, and appropriately wide, with a tube of 1 to 1¼ inches bore, gives a very suitable apparatus for ordinary use. By using a very large jar, or a large cylinder, and larger and much longer tube, a constant stream may be had for many days.



Professor Dewar recently exhibited, before the Royal Society of Edinburgh, two modifications of Sprengel's pump adapted to lecture illustration. In both instruments the mercury receptacle is made of iron, and, instead of the india-rubber joint of the original, a well-ground stop-cock, terminating in a Y-shaped piece bored out of the solid. In the one form the drop-tube is of glass, attached by means of marine glue; in the other, of carefully made india-rubber tube, 4 or 5 m.m. in thickness, of a very small uniform bore, made expressly for the purpose by the Edinburgh Rubber Company. The iron funnel-shaped receptacles are ground at the inner apex, so as to fit perfectly finely-ground iron tubes. By means of these tubes the preliminary exhaustions are made by a hand-pump, and then they are withdrawn. This device saves a separate joint. The barometer tubes are attached to solid T-shaped pieces of iron tube, and between these pieces and the main tubes each has a small glass bulb. Both forms work, for all practical purposes, as well as glass, and suit admirably for Frankland's water analyses, Graham's experiments, &c.

It would seem that the amount of ammoniacal gas absorbed by charcoal continually decreases as the temperature rises from 0° to 55°, but at that point a sudden change occurs, and the amount of gas given off becomes considerably diminished. In the case of cyanogen the absorption takes place very rapidly, being confined almost entirely to the first ten minutes, and the curve representing the absorption between 0° and 80° is continuous: the results obtained may be given in tables, and also represented by absorption curves. Hydrogen and nitrogen are very slightly absorbed by the charcoal.

M. Daubrée gives the following result of his examination of the rocks of native iron which were discovered in Greenland, in 1870, by M. Nordenskiold:—

Metallic iron		40·094	71·000
Iron combined with oxygen, sulphur, and phosphorus		30·015	
Carbon, combined		3·000	4·064
„ free		1·064	
Nickel			2·065
Cobalt			0·091
Sulphur			2·070
Arsenic			0·041
Phosphorus			0·021
Silicium			0·075
Nitrogen			0·004
Oxygen			1·210
Combined water			1·095
Hygrometric water			0·091
Soluble substances:—	Sulphate of lime	1·288	1·354
	Chloride of calcium	0·039	
	„ of iron	0·027	
Chromium, copper and loss			1·001

A process of printing on cotton or silk, which promises to be of practical utility, has been devised by M. Vial, of Paris. The cloth is first washed over with a solution of a salt of silver; then a coin, a medal, or a metal design —the metal being more electro-positive than silver—is placed upon it, and the design is produced by a deposit of silver in black lines in the fabric.

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The Hygiene of Air and Water. By W. Procter, M.D., F.C.S. *R. Hardwicke.*

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